

Ageless "Orville" on 75-Year-Old First Flyer

December 17, 1903—The real Orville Wright piloted this very Flyer on the first manned, powered, controlled flight of a heavier-than-air craft near Kitty Hawk, NC. A precious exhibit at the National Air and Space Museum, it evokes visitors' questions: "How do you clean it?" Gary Houston and photographer Dick Farrar show how. The Museum had a mannequin resembling Orville made in 1948. His left hand controlled aircraft pitch.

Wires from the hip saddle to wing tips responded to hip movement for wing-warping, the early way to control yaw and roll, turning and banking. Wilbur and Orville Wright built their own engine, to the pilot's right; it drove chains around two opposed sprockets to turn two propellers at the back in opposite directions. (More inside to help with classroom observances of the 75th anniversary of flight.)

SCAN

On October 1, the National Aeronautics and Space Administration (NASA) will mark its 20th anniversary. (For brevity, this publication often refers to its home as NASM. Readers are asked please not to confuse the two.)

The motivation for forming NASA, in 1958, had a little *deja vu* quality. Its predecessor, absorbed into the new NASA, was the National Advisory Committee for Aeronautics, also better recognized by its acronym. NACA had been established in 1915 to lead the U.S. in catching up with European advances in aviation. World War I incentives or not, the advances rankled, because after all the Wrights had started the whole business in the U.S. Incidentally, Orville Wright served in NACA for more than 20 years.

Again in 1958, the U.S. hastily created an agency, NASA, to lead the U.S. in catching up with another foreign initiative, the Soviet launch of Sputnik 1, October 4, 1957.

Students might enjoy discussing a thought of Dr. Herman Kahn's: "It's often better to be a fast second." Dr. Kahn is Director of The Hudson Institute.

The U.S. wasn't really second; it *had* space technology in the 1950s but no political incentive to use it. Today, however, the U.S. clearly leads in the scope of its high technology for both space and aviation. Aircraft of American manufacturers dominate world markets. NASA, as the cutting edge for aviation research, is working on such timely issues as noise reduction and fuel economy. Happy birthday, NASA.

TO FIRST-TIME READERS

Several thousand copies of this issue are going to educators who do not expect it, as a one-time introduction. Those who wish to continue receiving issues need to clip or photocopy the form on Page 15 and return it soon. There is no charge of any kind. All material may be freely photocopied for educational purposes.

NASM's Public Relations reminds those coming to Washington that Museum hours from September 5 on are 10 a.m. to 5:30 p.m., seven days a week. The Museum is closed Christmas Day.

A price list of all aerospace products available by mail through NASM's Spacearium Shop may be secured on request to Room P701; NASM's full address is on the back cover.

Briefing

Melvin B. Zisfein
Acting Director, NASM



I am faced with the unenjoyable duty of informing you that I am expected, in this column, to replace Michael Collins—Apollo 11 astronaut, former Director of the Smithsonian National Air and Space Museum, now Under Secretary of the entire Smithsonian, author of the best-selling book, *Carrying the Fire*, and (incidentally) one of the finishing runners in the 1978 Boston Marathon. If it helps round out the image, I know from personal experience that he also plays table tennis with exceptional skill, savage ferocity, and a total lack of mercy for us mere mortals. I'm sure that you'll join me in wishing Mike all the best in his new position.

Flying for Fun and Exploring Planets

At this time of change, I thought that you might enjoy a brief summary of work in progress here at the Museum. We have just opened a new gallery called "Flying for Fun," which features sailplanes, sport aviation, kites of many kinds, parachutes, hang gliders, boomerangs, flying discs and Frisbees. It's a colorful gallery and the objects, labels and display techniques go beautifully with each other to make the visit almost as much fun as flying.

We are also hard at work on another new exhibit gallery to be called "Exploring the Planets." The exhibit will feature the many facets of the unmanned exploration of our Solar System. It will contain "goodies" like the "Mars Overflight Unit" in which the visitor looks through a special lens at an appropriately detailed and illuminated moving Martian relief construction to get the illusion that he or she is flying in orbit over Mars.

Another novel unit in this gallery will be the "Descent to Venus" in which the visitor steps into a year-2250 spaceship to become a well-protected space tourist of the future. The spaceship with its visitors first approaches Venus and then penetrates its dense and noxious atmosphere to land finally on its 900°Fahrenheit surface for a video "look around."

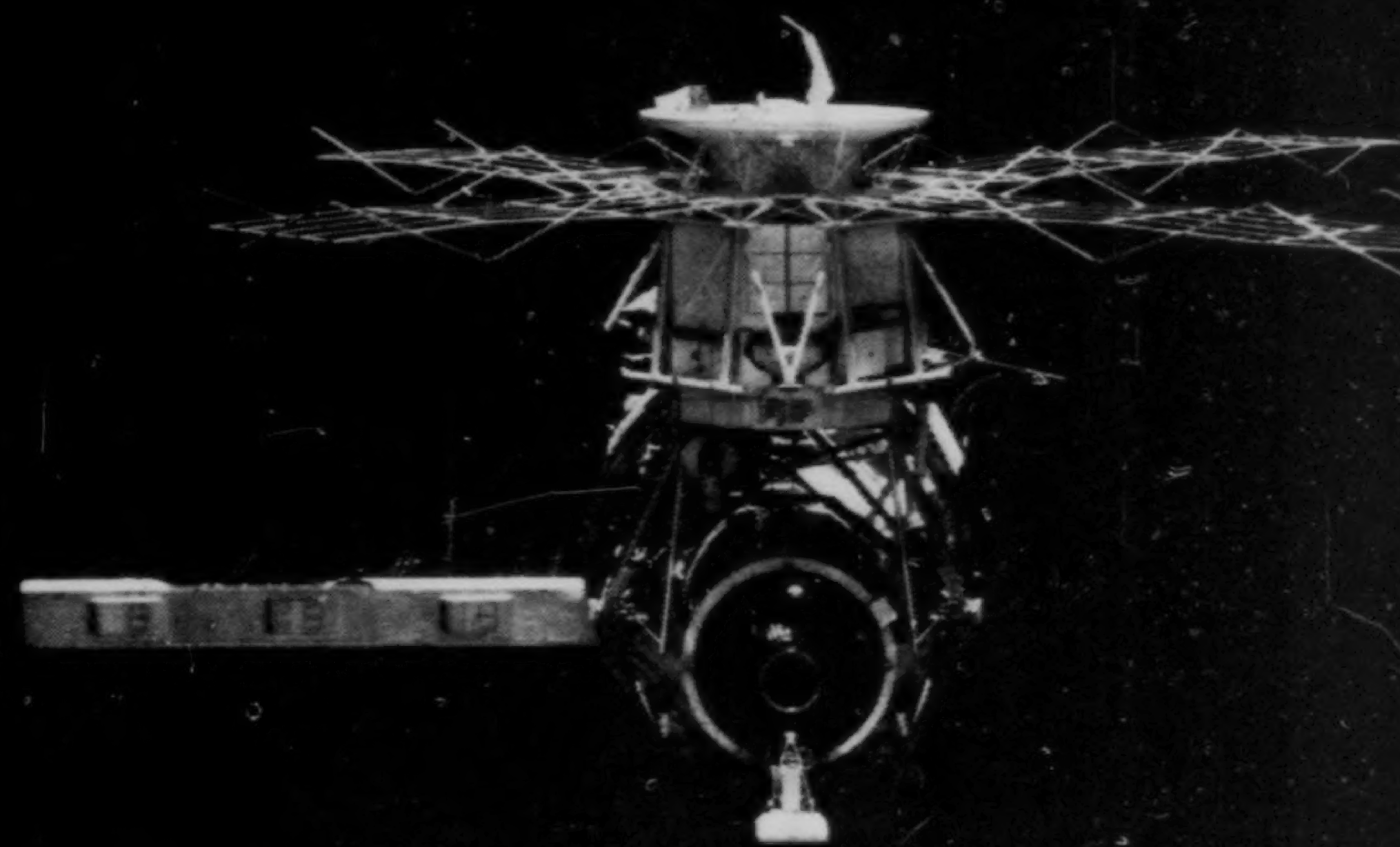
Live Demonstrations To Come

Our next major exhibit improvement is slated to be our Center for Live Demonstrations in which members of our educational staff will present at frequent intervals adult and children's shows directed at understanding why an airplane flies and how it's controlled, and why a rocket engine is used to get us to the Moon, what you can see and learn from orbiting satellites, and other popular questions. We won't be satisfied until we have developed presentations that really explain to the average museum visitor all of the important aspects of flight.

The improvements that I've described so far are just our pending exhibits. I've no more room for the substantial remainder of our new efforts in areas such as publishing, restoration, education, theatrical presentations, lectures and symposia; more about these in our next issues.

The Skylab missions provided a number of lessons valuable to the planning of future space habitats. One unexpected but potentially important biological observation resulted from a minor and largely unrecognized incident on Skylab 4.

H. William Scheld



Serratia marcescens in Skylab

by Dr. H. William Scheld
Senior Research Scientist
Department of Biology
University of Houston

Dr. Scheld's experiments have flown on U.S. and Soviet biosatellites; he is now preparing one for a Shuttle flight. He has taught Space Biology at John Carroll University and advises universities on student participation in space research.

There was concern for possible harmful interaction of the space environment and microbes naturally found in the human system. Therefore, extensive microbiological sampling of crew and spacecraft was carried out during the Skylab missions. Air and crew samples taken one day on Skylab 4 differed markedly from previous missions:

"Low levels of in-flight bacterial contamination were observed on the first two missions, whereas the recovery from Skylab 4 was considerably higher. These higher counts were due entirely to an influx of *Serratia marcescens*, a microorganism which had been shown to produce various infections in man.*

"Whereas this species was not recovered from any preflight crew sample analysis, it was recovered from multiple sites from all three Skylab 4 astronauts immediately upon recovery. Further, this species persisted in the nasal cavity of the Pilot throughout the postflight quarantine period.

"Subsequent investigation demonstrated several potential sources of this organism in the Skylab environment. However, these potential sources could not be sampled in-flight and, therefore, a direct correlation could not be made."

(Brockett, et al., 1974; *Proc. Skylab Life Sci. Symp.* Vol. 1 p. 121. NASA TM X 58154)

*Wilfert, et al., 1970. *Appl. Microbiol.* **19**, 345. (*Serratia* is common in soil, water, and on plants, and does not infect healthy, unbroken skin.)

As a practical matter, there was adequate circumstantial evidence that the *Serratia* influx observed in Skylab 4 originated from a minute amount of aquatic plant material exposed briefly to the Skylab atmosphere during early weeks of the mission.

The apparent source of the organism was plant material (*Elodea* leaves) carried into orbit in a student experiment which investigated the effects of zero gravity upon cytoplasmic streaming. A post-flight search for possible sources of contamination revealed that the demonstration package of the experiment, prepared with the flight package and installed in the Skylab training mockup at the time of launch, contained large red bacterial colonies apparently of *Serratia* associated with the dead *Elodea* leaves (Scheld, Laboratory Diary).

The means by which this small contamination was able to increase to the observed levels are of basic interest. One interesting although far-out possibility is suggested by experiments designed to test whether spacecraft-carried organisms could survive and proliferate in Jupiter's atmosphere. The results of these experiments, which employed *Serratia* as the test organism, are interpreted as indicating that such bacteria can divide and grow suspended in the atmosphere.** The Skylab 4 experience with *Serratia* may have added confirming evidence.

More mundane possibilities are that organisms may have been continuously liberated into the air from some contaminated surface in the wardroom; may have been on skin particles constantly liberated from active humans; or may have been liberated in nasal discharge of the pilot. In any case, the *Serratia* incident should serve as a warning that there may yet be things we do not understand about microbial interaction with the space environment.



Returning to Earth, the crew of Skylab 4 photographed the spacecraft where they had spent 84 days, a record recently broken by the Soviets. Left, mannequin seems to reach for a weightless object in the backup Skylab at NASM.

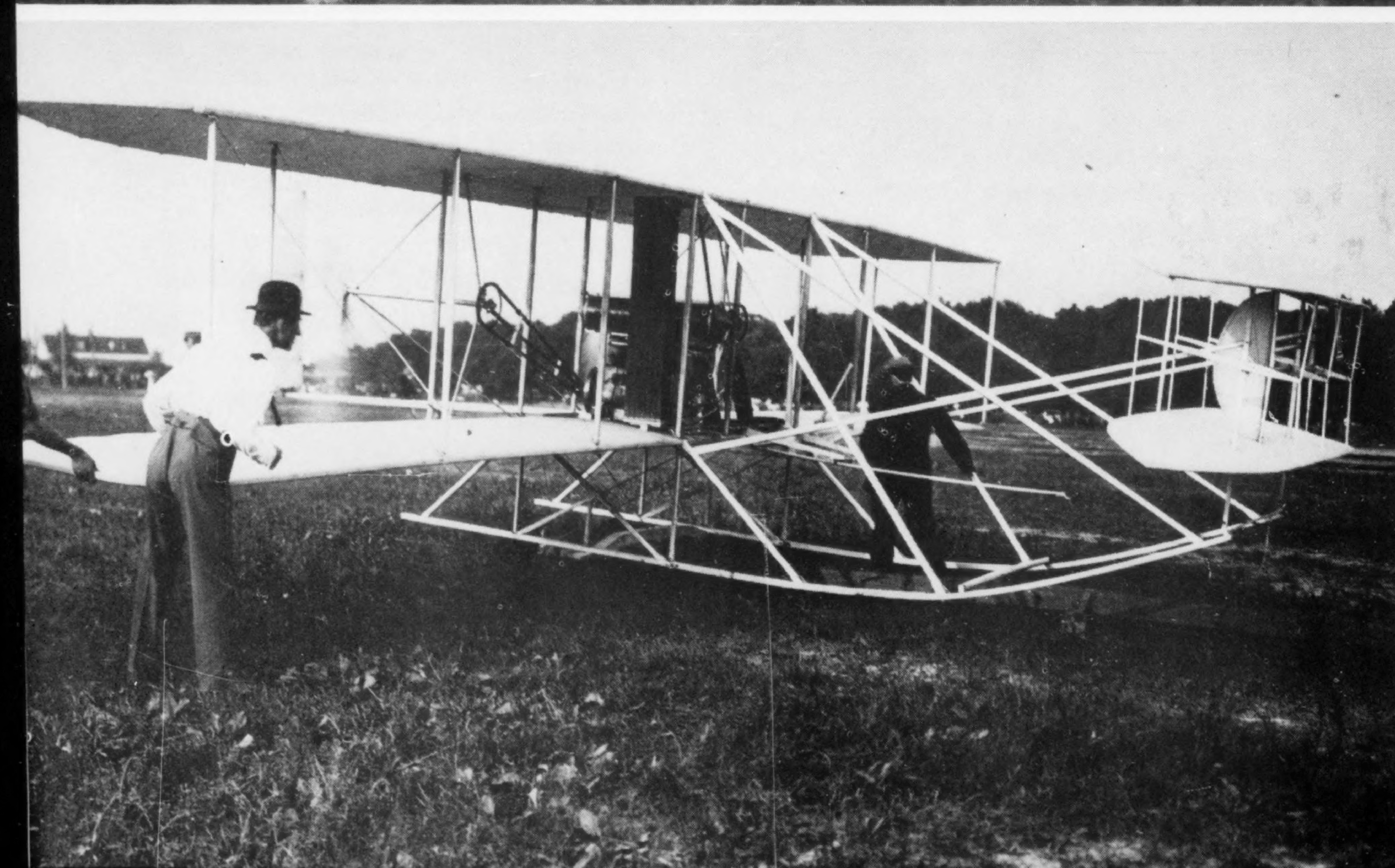
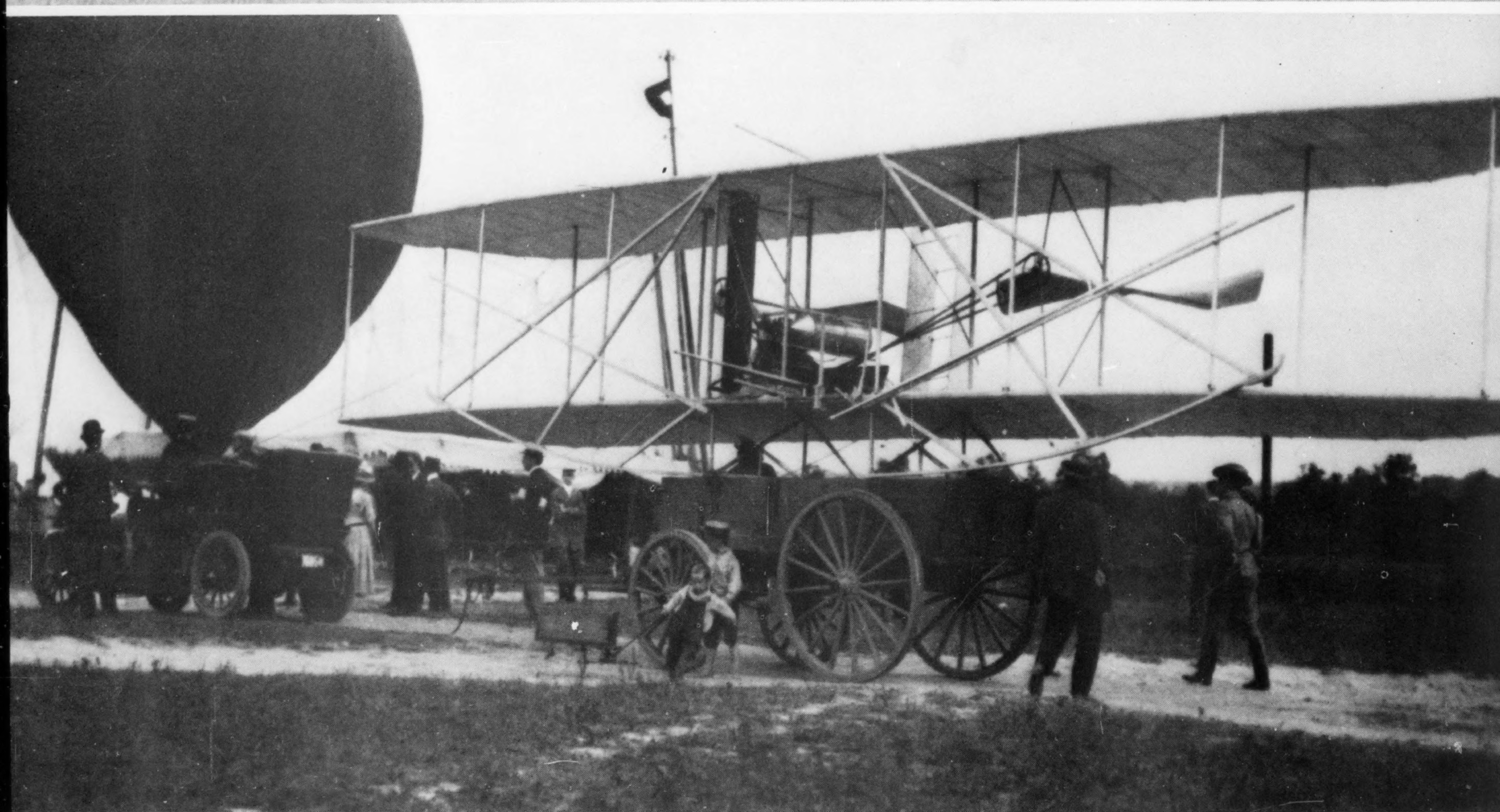
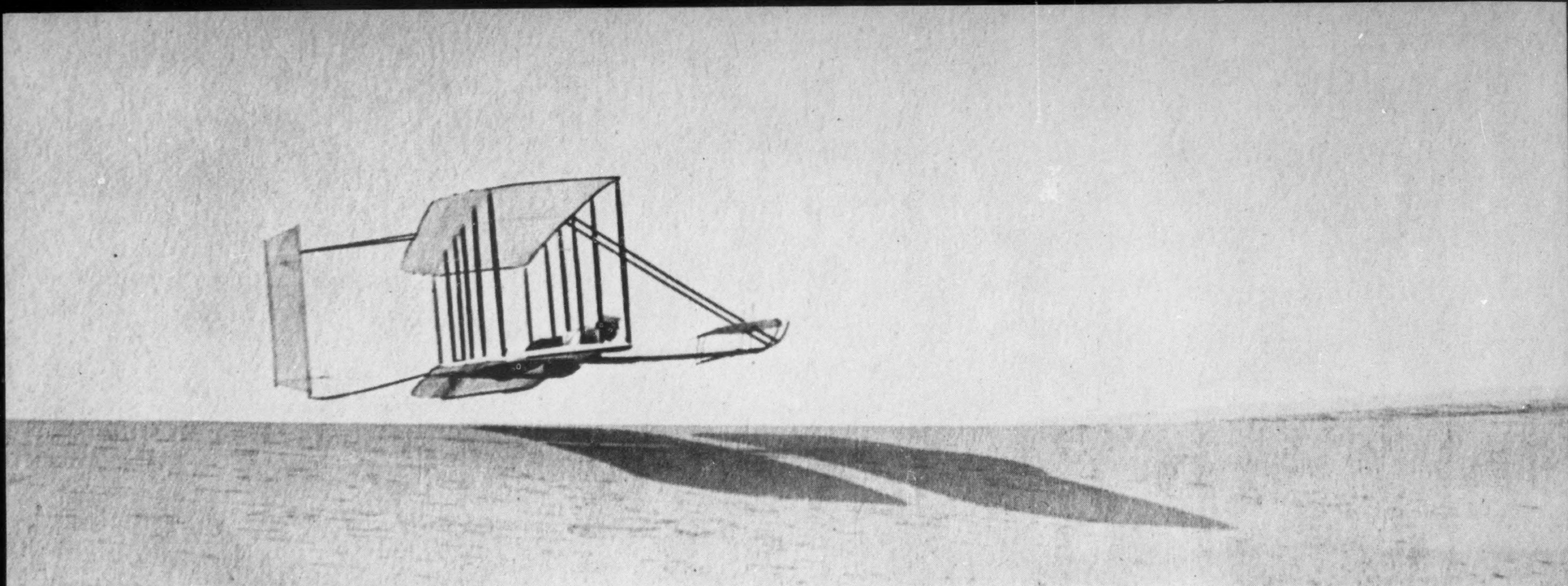
Could Skylab Be Re-used?

Air & Space asked Dr. Scheld if he thought Skylab could be safely occupied again, if it survives.

"Skylab was probably becoming a fairly dirty place by the end of the mission, but I doubt seriously if *Serratia* contamination is any longer a potential problem," he wrote. "I believe the last crew let their artificial atmosphere out of Skylab. What may be of interest is to see how many of those original organisms which may have been deposited on surfaces are still viable. The measured population density in Skylab air was only about 300 colony-forming units (e.g., live cells or small groups) per cubic meter. That itself is not very high, but seldom do we find a situation where one organism predominates. Chances of problems are generally higher when one organism becomes dominant.

"Reuse of Skylab may be very costly. It was made to be a throw-away and to be maintained at low atmospheric pressure with an oxygen atmosphere (highly explosive if you don't select materials carefully). The cost of renovating and remodeling with permanent life support facilities, using flame-proof materials, or reinforcing to take normal pressure (14.7 psi) may be much greater than replacing Skylab with an entirely new structure of more current design. The main reason I can see now for kicking it into higher orbit is to prevent possible embarrassing situations when the orbit decays enough to let it fall in on us. I am told that parts of it are too massive to burn completely upon re-entry."

**Dimmick, et al., 1976, *COSPAR Proceedings*, Philadelphia.



Top: photograph of Wrights' modified 1902 glider; the former two fixed rear fins are replaced by a single rudder operated by the pilot in concert with the wing-warping (later, operated separately).

Middle: 1908 Flyer at Fort Myer, Virginia, for demonstration to the Army. One military specification for an acceptable plane was that it must fit a standard wagon for transport.

Left: 1909 Flyer, built to military order for \$30,000. Wilbur is at wing end; Orville lifts tow bar between landing skids.

December 17, 1978 — 75th Anniversary of Flight

Students should relish the great suspense story:

After 18th and 19th century efforts to build a flying machine, who would it be, finally, to combine all three requirements:

1. A shape for a heavier-than-air vehicle which would utilize air currents for sustained lift, i.e., stay up.
2. An engine for propulsion, powerful enough yet light weight.
3. Controls for motion on all three axes (pitch, roll and yaw).

December 17, 1903 — Triumph at Kill Devil Hills

Two brothers from Dayton, Ohio, had come several times to the wind-swept dunes called Kill Devil Hills, near Kitty Hawk, North Carolina. Their choice of a place for testing their gliders had been as methodical as all their other steps toward discovering principles of flight. They had written to the Weather Bureau for nationwide data on winds.

They were not trained engineers, but the family was intelligent and resourceful. For a living, the brothers built and repaired bicycles. In spare time, they set themselves to learn all that was then known about flying machines. For instance, they built their

own wind tunnel for studies of aerodynamic lift and improved on the work of many others. They wrote to the Smithsonian Institution for information, and corresponded widely to follow news of others who were building craft and trying to fly.

Among them was the Secretary of the Smithsonian himself, Samuel Pierpont Langley. His large Aerodrome twice failed because of the extreme inertia of the catapult used to launch the plane over the Potomac River in Washington. He gave up after the second attempt—on December 8, 1903.

December 17 was a blustery, cold day at Kill Devil Hills. The Wrights

had brought from Ohio a new version of their successful glider, this one, however, powered by an engine they built themselves in order to get one light enough. They set up a camera and had witnesses. The Flyer which now hangs in this Museum headed into the wind—and made history.

Details of Wilbur and Orville Wright's four flights that day, and subsequent events that opened The Air Age, can be found in many books. Below is a story on the most notable aspect of their achievement by an historian who, as a boy, saw the Wrights' demonstration which "sold" the U.S. military on aviation.

The Invention of Airplane Control

by Paul E. Garber
Historian Emeritus, Ramsey Fellow
National Air and Space Museum

This year we will celebrate a significant anniversary relative to a marvelous invention. Seventy-five years ago, Wilbur and Orville Wright accomplished the first flight in an airplane under power and control.

"Control" is the important word.

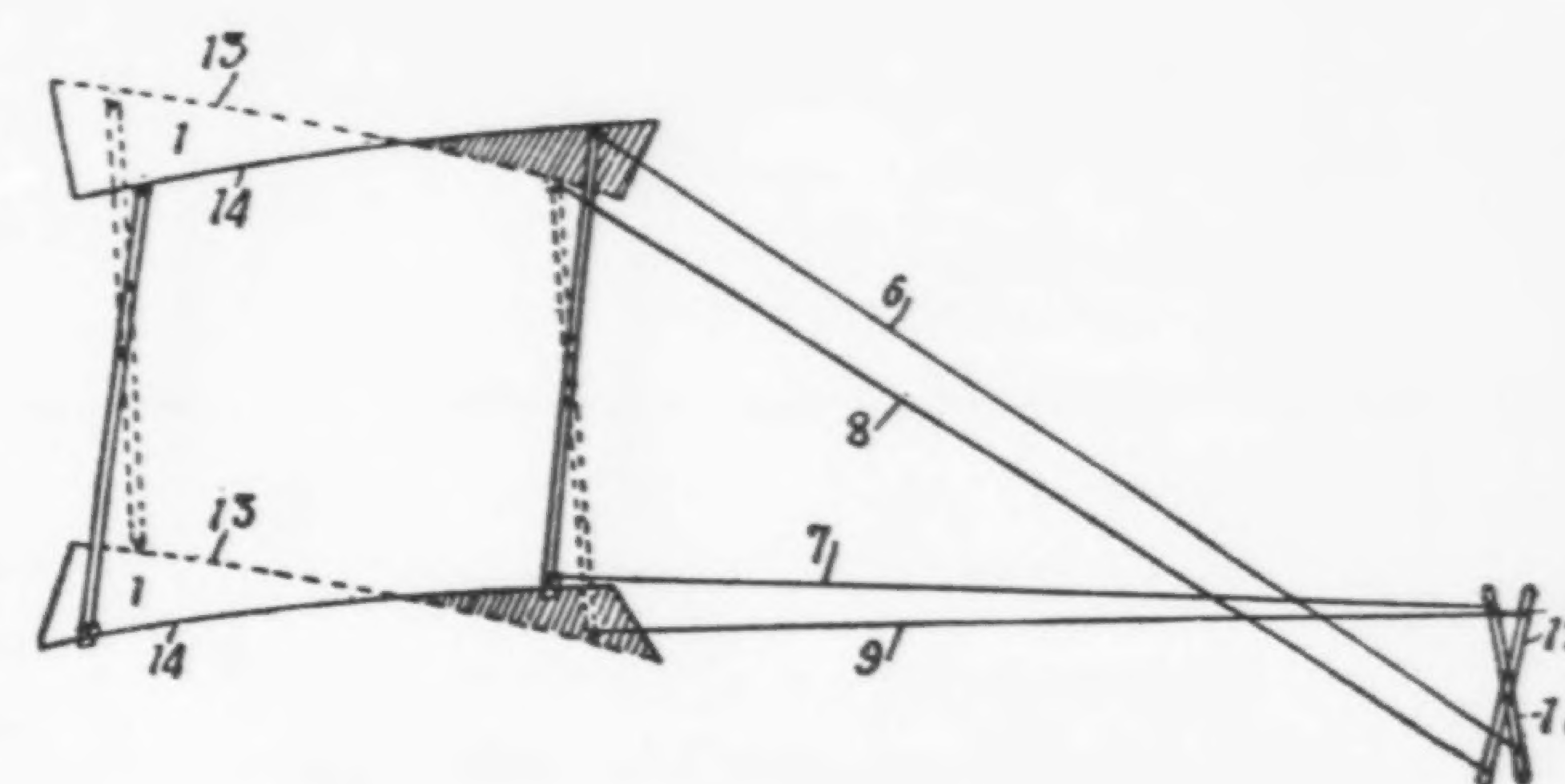
For thousands of years, persons had been trying to fly. The birds' way of going from place to place seemed so easy and sensible. Just jump off a limb, flap your wings up and down, and off you go. No roads to make, no hills to climb, no rivers to swim, no tunnels to dig, no detours.

So men tried to make wings for themselves, but didn't have the knowledge and power needed for flight. Persons don't have big breastbones protruding out in front to which

powerful muscles can be attached for flapping wings. Birds do. But mankind has brains more useful than those of any other creature, so he used them.

In 1783 a man first rose in a balloon but he was merely floating in the air. He had no control for steering and had to go wherever the wind might blow him. Adding an engine and propeller occurred 70 years later. That helped to steer the balloon but progress was slow. By the latter years of the 19th century, men had learned how to coast on the air in gliders, but control was limited, and fatal accidents occurred. The Wright brothers became interested in control when they made their first aircraft. It was a kite.

As boys they enjoyed making and flying kites and they soon learned that unless their kite was properly shaped and balanced, with its bridle and flying line correctly attached, the kite would



Wilbur Wright's sketch of the box kite, five feet wide, with cords which provided experimentation in control through wing warping.

not fly and they couldn't control it. That was a boyhood interest.

In 1896 when Wilbur was 29 years old and Orville was about four years younger, they read about Otto Lilienthal of Germany who had developed skill in making and piloting gliders. But he had lost control during his last glide and died the next day from injuries. The brothers wondered why.

Knowledge begins with wonder, if we advance beyond the wondering

Continued on next page

INVENTION . . .

Continued from preceding page

and try to learn the reasons.

So, as thousands of other persons have done, Wilbur Wright sent a letter to the Smithsonian Institution, where the staff, the files, the library and exhibits provide answers to millions of questions. The brothers learned that the head of the Smithsonian, Samuel Pierpont Langley, was experimenting with large, unmanned, powered models of airplanes. In his letter, Wilbur explained that he had been interested in flight ever since he was a boy and made models and kites; he believed that human flight was possible and wanted to study the associated problems.

Toward the end of this letter he wrote a beautiful sentence: "I wish to avail myself of all that is already known and then if possible add my mite to help on the future worker who will attain final success." A mite is a very little bit, but as we think of all that Wilbur and his brother did to achieve final success, that word could have been spelled "might."

The Smithsonian's reply enclosed pamphlets describing the work of several pioneers of aviation, and suggested that they read publications by Octave Chanute and James Means. Chanute's book was called *Progress In Flying Machines* and described the author's studies of every aircraft of which he could find record. He was a very capable engineer who had made and tested kites and man-carrying gliders. His subsequent correspondence and visits with the brothers were very helpful to them.

James Means had retired from bus-

iness; he studied flight by making and flying kites and model gliders. He assembled accounts of flight experiments in a series of *Aeronautical Annuals*, published 1895 through 1897. Thus, the Wrights learned what others had done and became especially interested in the box kite invented by Lawrence Hargrave of Australia in 1893. They decided to make a box kite but modify it so they could control it.

The usual form of box kite, providing it has been properly made and bridled, will fly at an angle and height depending on wind velocity, lift and the length of flying line. It is up there to be admired and enjoyed. But the Wright brothers wanted to do more than just fly their kite. Theirs had a front cell, and behind, was a flat horizontal surface extended on a stick or boom attached to the central rear strut of the front cell. Today such a surface is called a stabilizer.

They flew their kite with four lines, each line extending to an outer front corner of the cell (see Wilbur's drawing on Page 5).

The two lines from each side of the kite extended to the top and bottom of a stick about two feet long. The flier held a stick in each hand, vertically. When the hands were moved forward and backward, alternately, the kite was pivoted on its vertical axis. To get the feel of this, pick up a pencil and hold it vertically. With the thumb and finger of the other hand rotate the pencil one way and then the other. Think of it as a pivot on which an airplane is turning as the pilot steers to right or left.

Controlling an airplane requires more

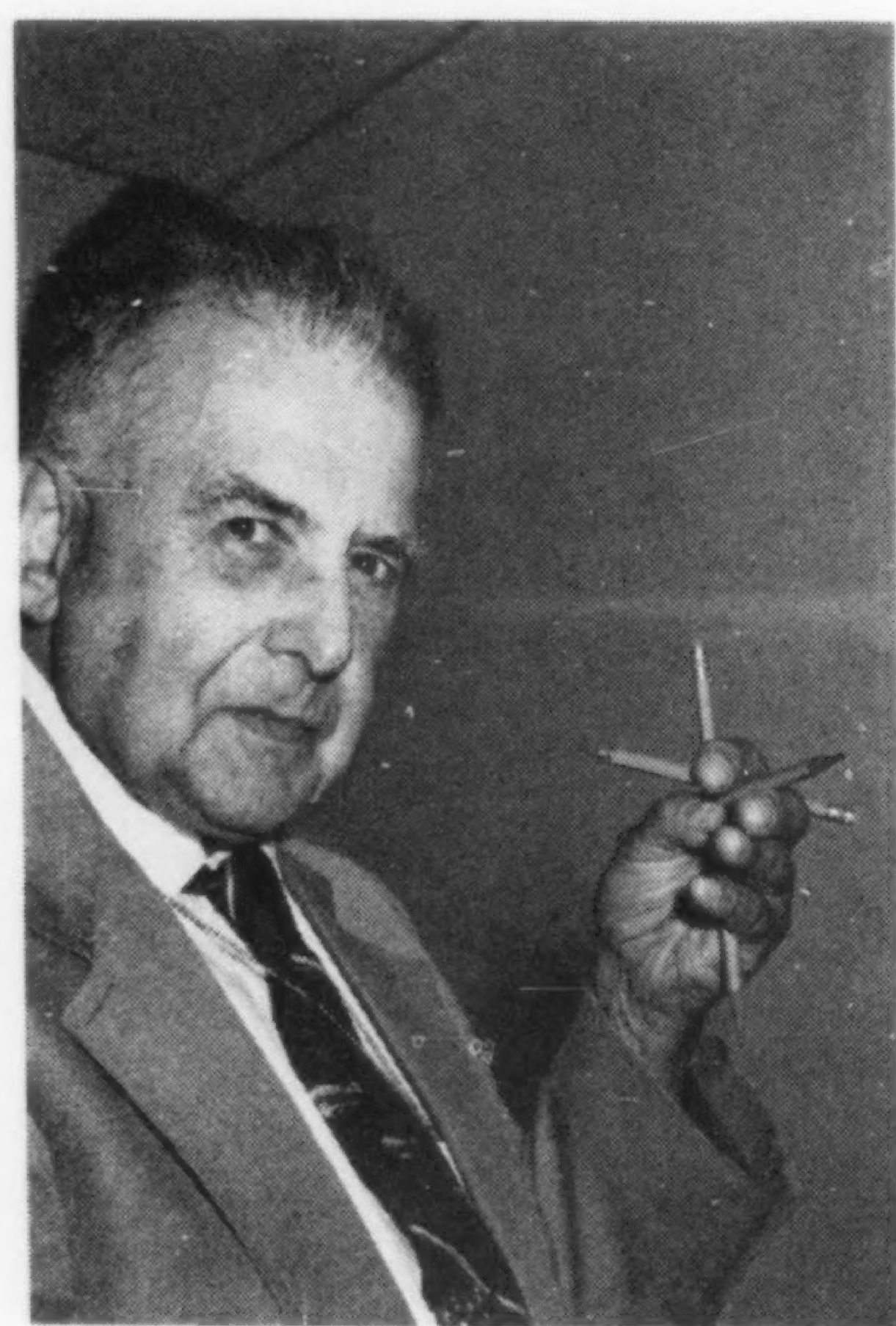
than one axis of movement. In addition to the vertical axis, the airplane must have control for up and down, and for sideways balance. To practice up and down control with their kite, the Wright brother flying it would move the sticks with a wrist twist, both the same way, back and forth, like a rocking chair. To have the movement more instinctive, they decided to cross the lines, so that moving the tops of the control sticks backward would incline the kite at an upward angle to make it climb. That's the same way that the control stick moves in an airplane today—pull back and up you go; push the stick forward, and down you go.

With the Wright kite, the "pilot" had to be quick on the reverse control when he had inclined the kite downward, because with its leading edge depressed, the kite lost lift and headed to Earth. To get the feel of this second axis of control (what a pilot calls "pitch"), put that vertical axis pencil back in your hand and lay another pencil horizontally against it, held by the thumb. Now by wrist action you can imagine that you are maneuvering an airplane in two axes of control, in right or left turns, and climbing or descending.

To practice and study the third axis of control, which is sideways balance, the Wright kite was twisted end to end. The brothers called this "wing warping" and did this by tilting the control stick in one hand backward, and the other forward, using wrist movements, not moving the arms. If you were looking at the sticks from the side, they would appear like an "X." This warping caused the kite to tilt downward on one side or the other, depending on which way the sticks were criss-crossed. Thus the brothers could experiment with lateral control or sideways balance. To understand this better, put two pencils back in your hand, one vertical, the other horizontal, and put a third pencil straight ahead over the horizontal pencil and close against the vertical. Now you have three-axial control and you're all set to fly your imaginary airplane anywhere and keep straight and level in spite of any air turbulence. A modern pilot calls sideways balance "roll" and controls it with ailerons instead of by warping the wings.

Experimenters have improved wings and power since the beginnings, but not until October of 1902, when the Wright brothers were flying and improving their third glider, was three-axial control developed.

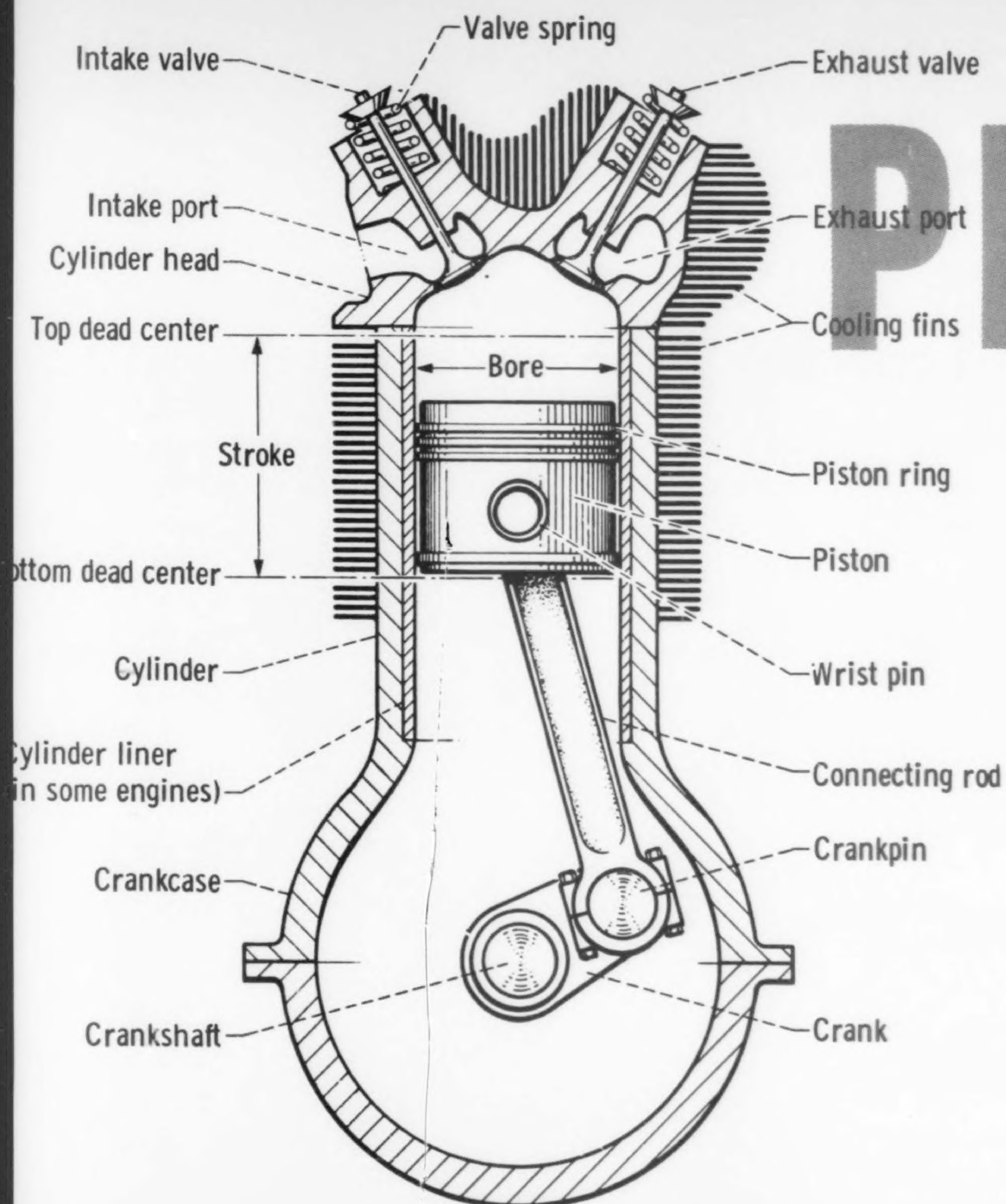
And that invention made powered flight possible.



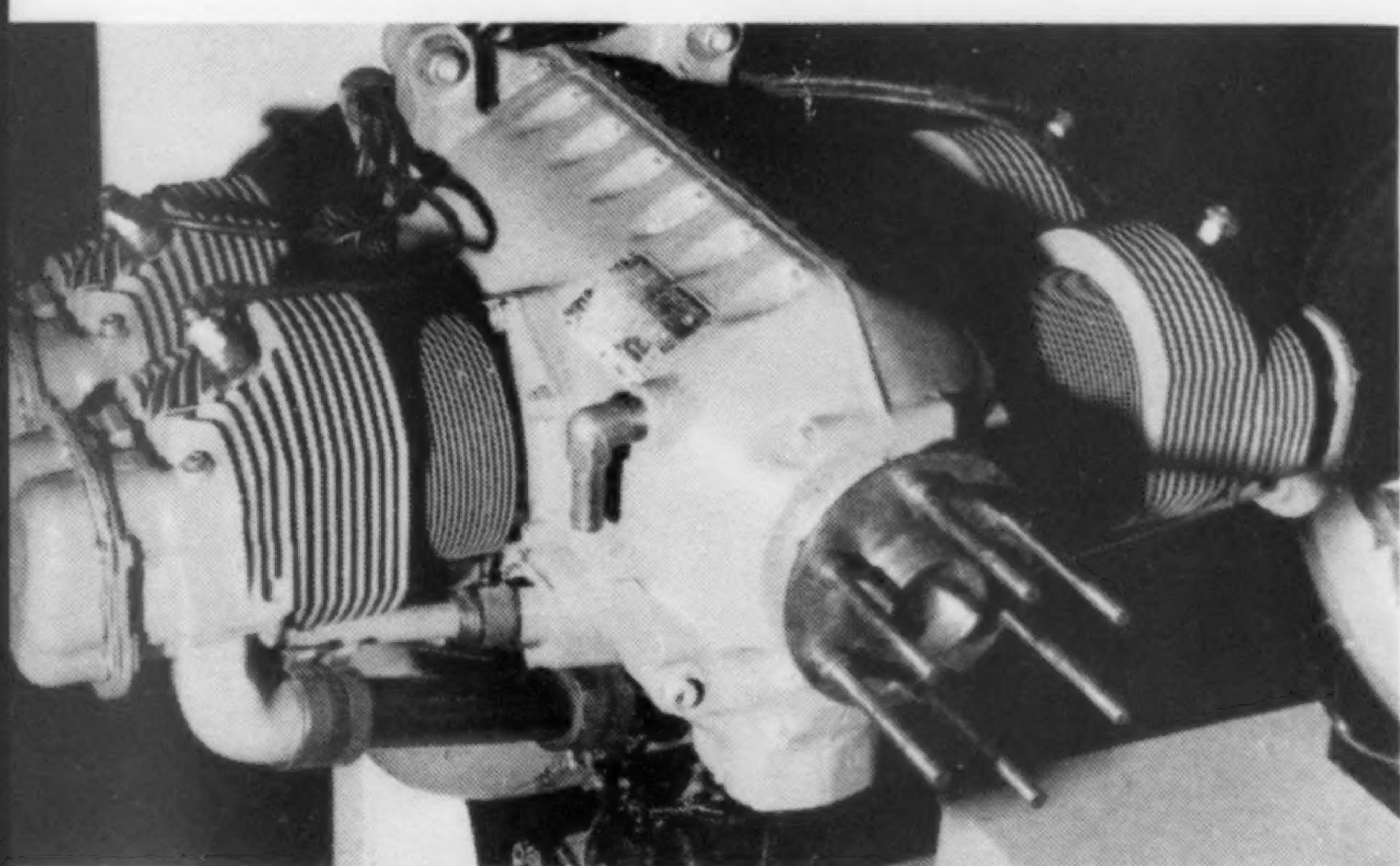
Paul E. Garber illustrates with pencils the three axes of aircraft motion which the Wright brothers were first to control. At age 10, in 1909, Garber rode a Washington, DC, trolley to Fort Myer and saw one of the Wrights' demonstrations for the military. He remembers "the staccato noise of the engine. I was astounded. I had often seen my homemade kites in the air but here was an enormous two-winged aircraft with two men seated in it, its engines roaring, its propellers whirling, the whole marvelous machine soaring right over my head."

Mr. Garber knew most of the leaders of early aviation. He joined the Smithsonian in 1920, became the first Curator of the National Air Museum.

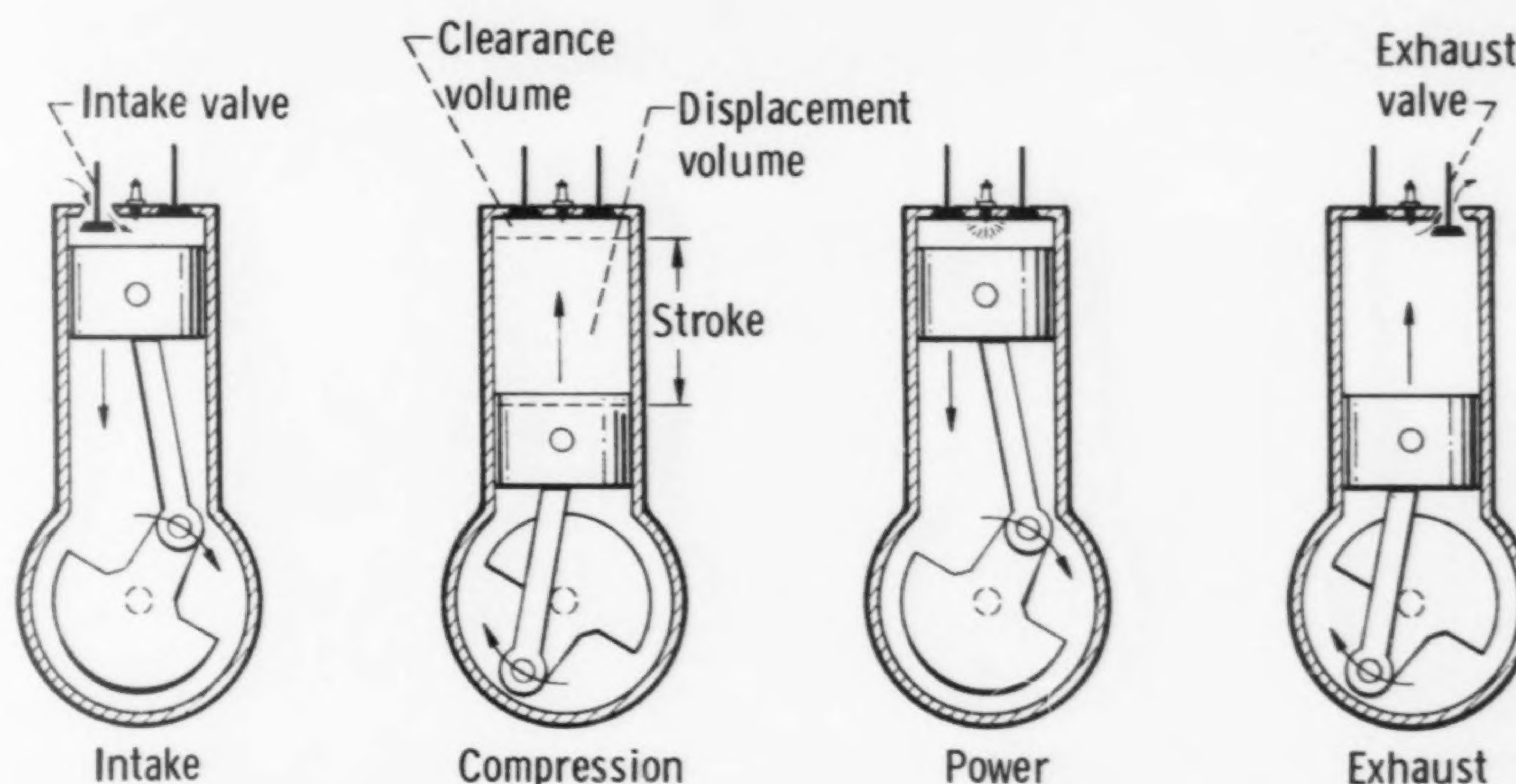
PROPULSION



Flying faster and farther—that's always been the prime criterion in aviation. Air races with their coveted trophies, the demands of two World Wars, then the commitment to put men on the Moon spurred advances in engine design and other factors that contribute to speed. In only 66 years (1903-1969), aerospace propulsion went from 12 horsepower in the Wrights' engine to 30,000 equivalent hp in the turbopump of each of five rocket motors clustered as Stage 1 of the Saturn V Moon-launch vehicle, and more than 65,000 equivalent hp in a jumbo jet engine (near sea level). What next? Engineers believe they can solve the current problems of commercial supersonic flight, of pollution control, noise abatement and fuel economy. They design for special functions, as vertical takeoff, and look at alternate power sources which, someday, may make chemically fueled engines seem primitive.



Top: The Continental A-65-8 engine of 1939—4 cylinders horizontally opposed, air cooled, 65 horsepower on takeoff. This engine in the Piper J-3 Cub airframe (lower photo) promoted the great growth of sport aviation. During World War II, the A-65-8 was the U.S. Army's standard for all light liaison aircraft. Many homebuilt airplanes still use it, according to the Experimental Aircraft Association. The engine on exhibit at NASM was a gift from the Rochester (New York) School District.



The powerplant which Wilbur and Orville Wright built in 1903 was a reciprocating engine with four cylinders operating as diagrammed above. This type engine is so efficient at speeds under 560 kilometers per hour and at altitudes under 9 kilometers that still, today, more than 8 times as many aircraft in the U.S. fly with such engines as use the newer turbojets, according to Robert B. Meyer, Jr., NASM's Curator of Aero Propulsion.

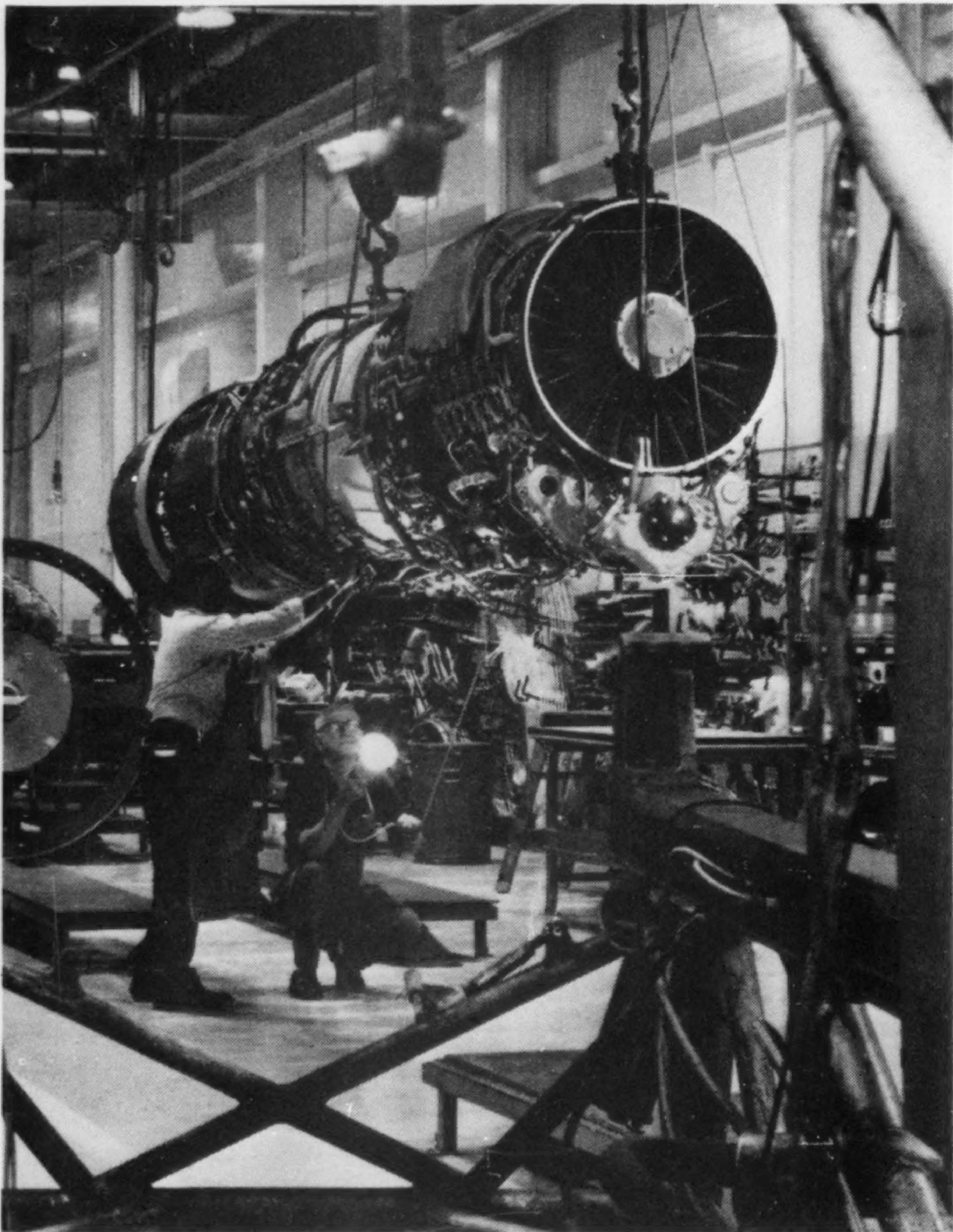
To fly faster and farther required another kind of engine. The quantity of oxygen available determines how much fuel can be burned, and how much power can be produced. At even six kilometers altitude, air (21 percent oxygen) is less than half as dense as at sea level. Therefore, planes operating in thin air must compress what's available in order to keep an engine from becoming "breathless"—like cars and athletes at high altitudes. The jet engine does just that, with its compressor fans at the front. The rocket

for launching spacecraft needs stupendous power and carries its own super-efficient oxidizer. This may be very cold liquid oxygen, or part of the mix in solid propellant.

It was a student cadet in England, Frank Whittle, who in 1928 revived long-standing theories about a gas turbine engine without a propeller. He made drawings and wrote a thesis. But actual flight of a jet engine did not come until 1939 in Germany and 1941 in England.

Jets and rockets are reaction engines, illustrating Newton's Third Law: Every action provokes an equal and opposite reaction. Jets exhaust mass (hot gases of combustion), using the entire engine casing as a tube for continuous flow, heating and exhaust; and the entire engine feels the forward reaction thrust. On Page 10 is a chart comparing reciprocating, jet and launch engines, with mention of radical new ideas about engines useful only in the vacuum of space.

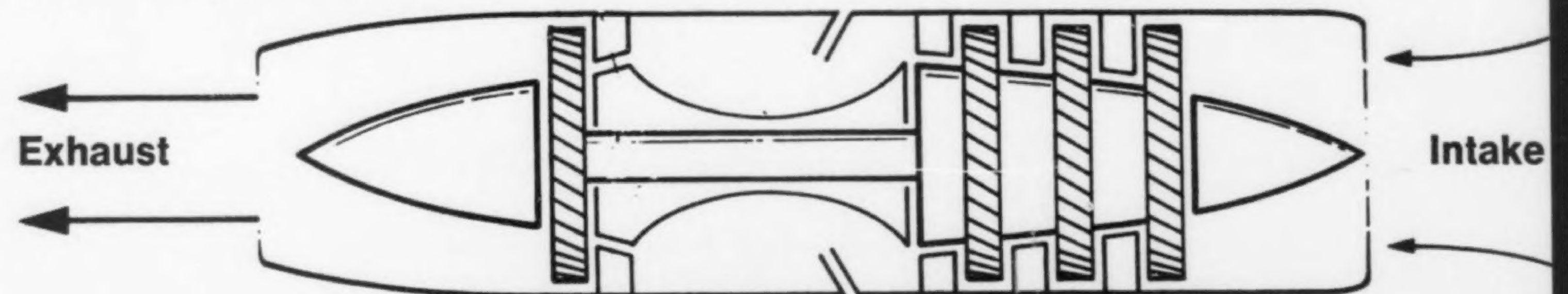
JET ENGINES



Jets and rockets both satisfy Newton's Third Law. Both expel gases of combustion (action) and in *reaction* are propelled forward.

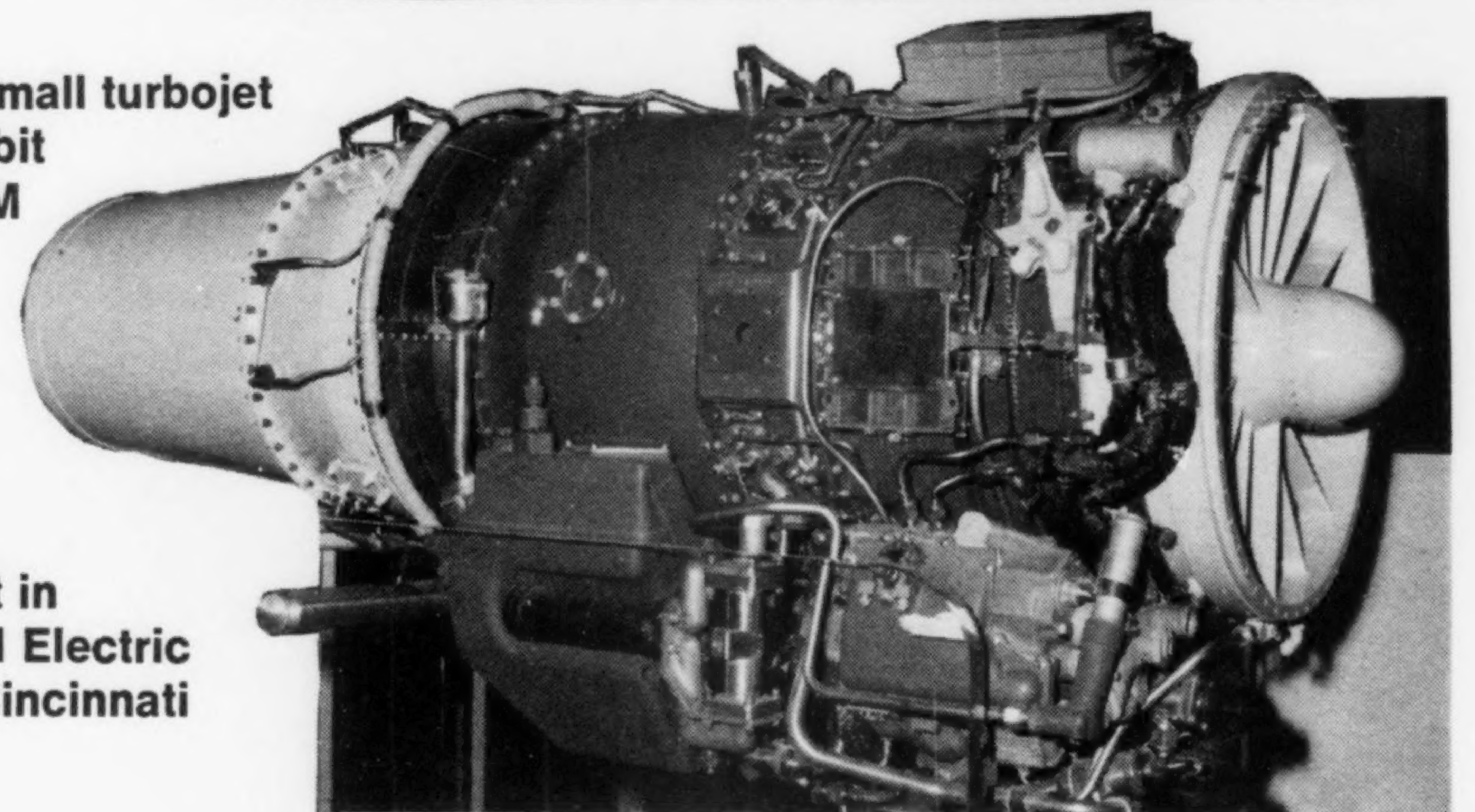
1. TURBOJET

Four-step operation, R to L: Air intake, compression, combination with fuel for combustion, and exhaust, some of which powers a turbine that turns compressor fans.

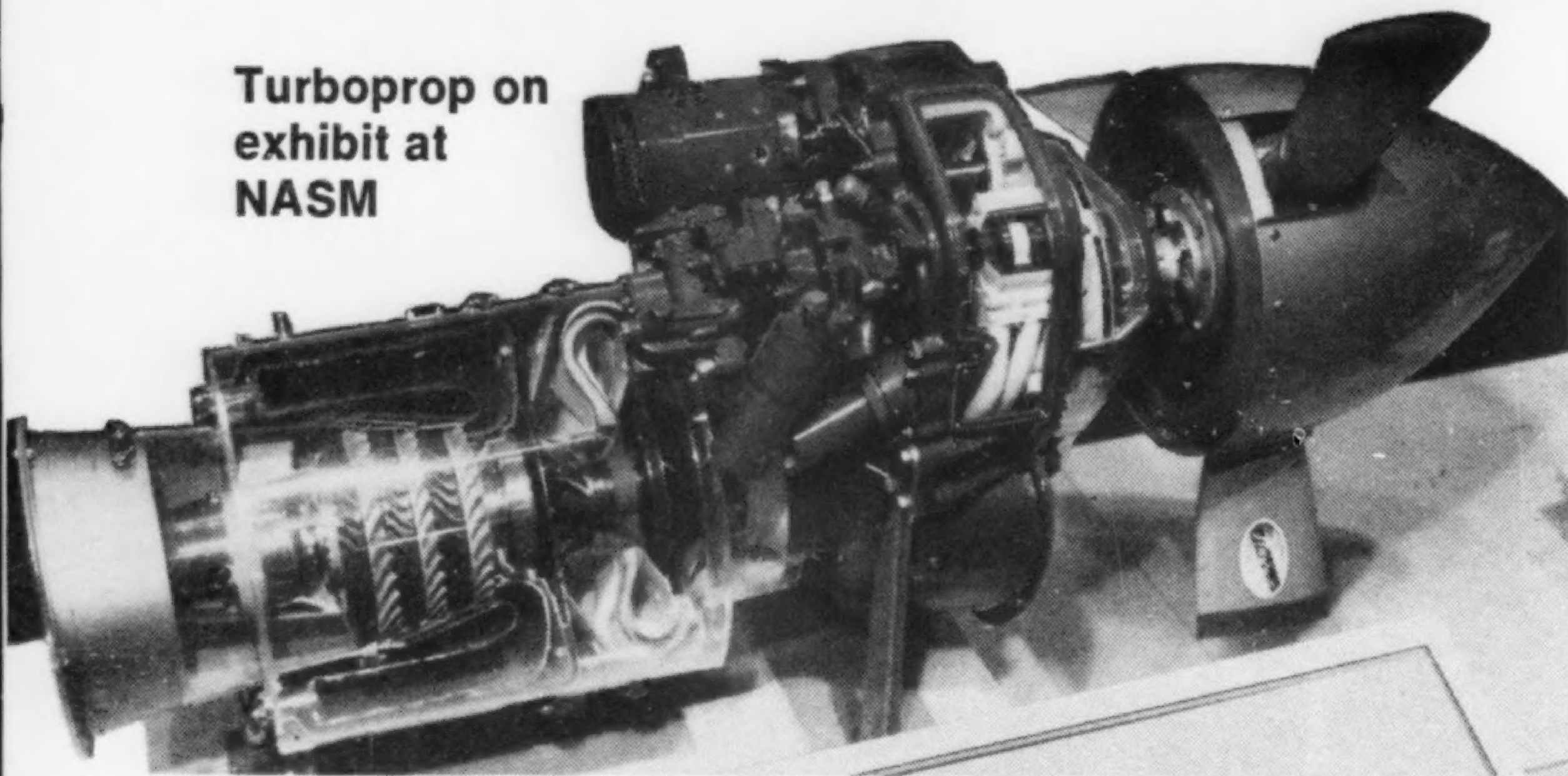


Right, small turbojet on exhibit at NASM

Left, turbojet in General Electric shop, Cincinnati

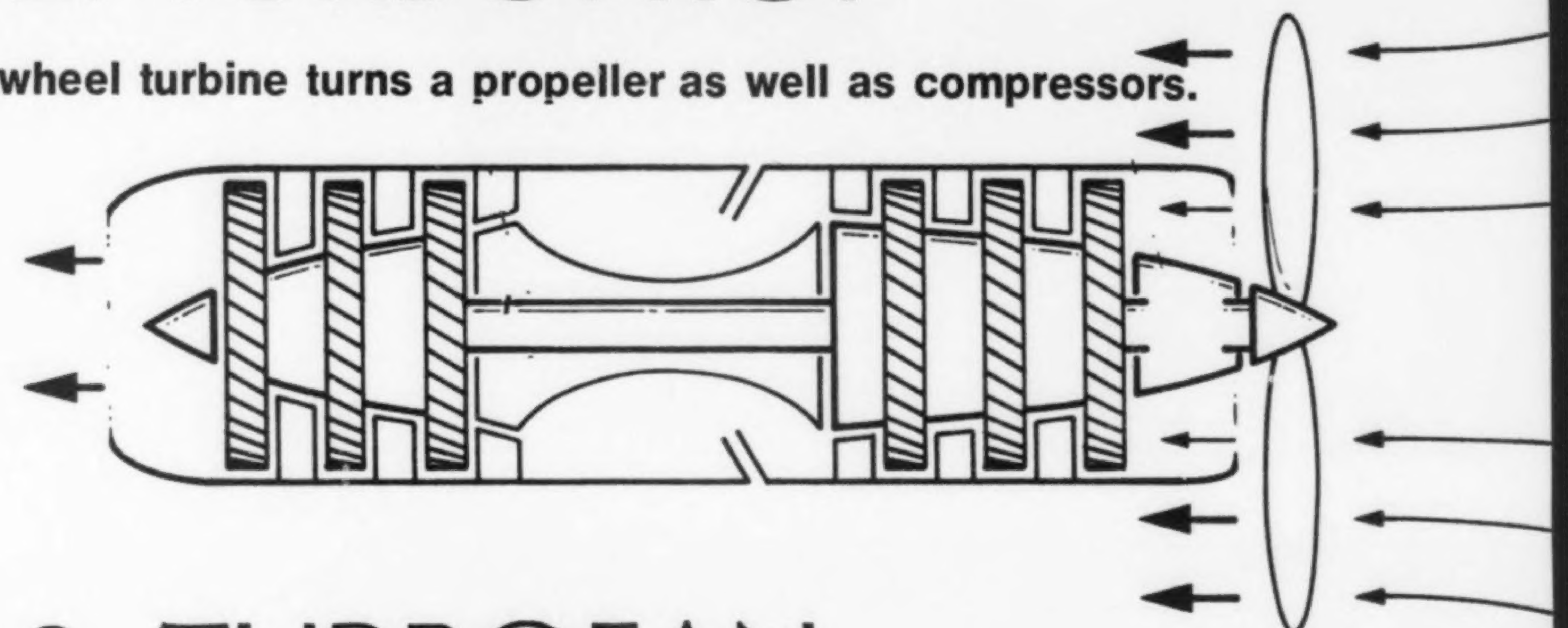


Turboprop on exhibit at NASM



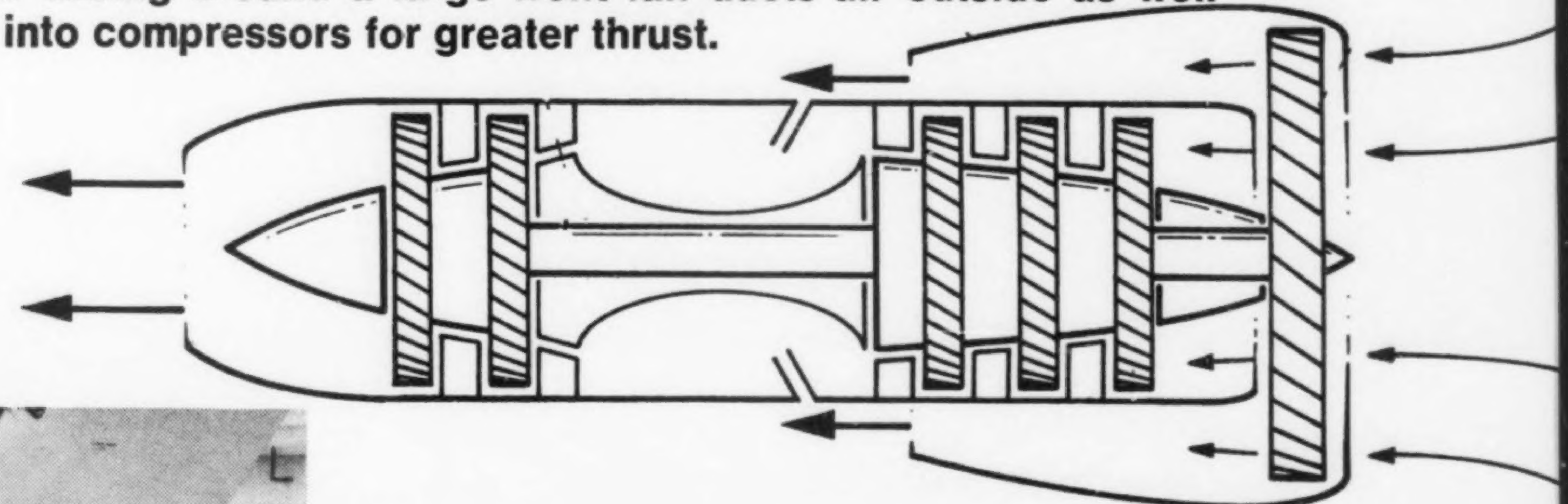
2. TURBOPROP

Three-wheel turbine turns a propeller as well as compressors.

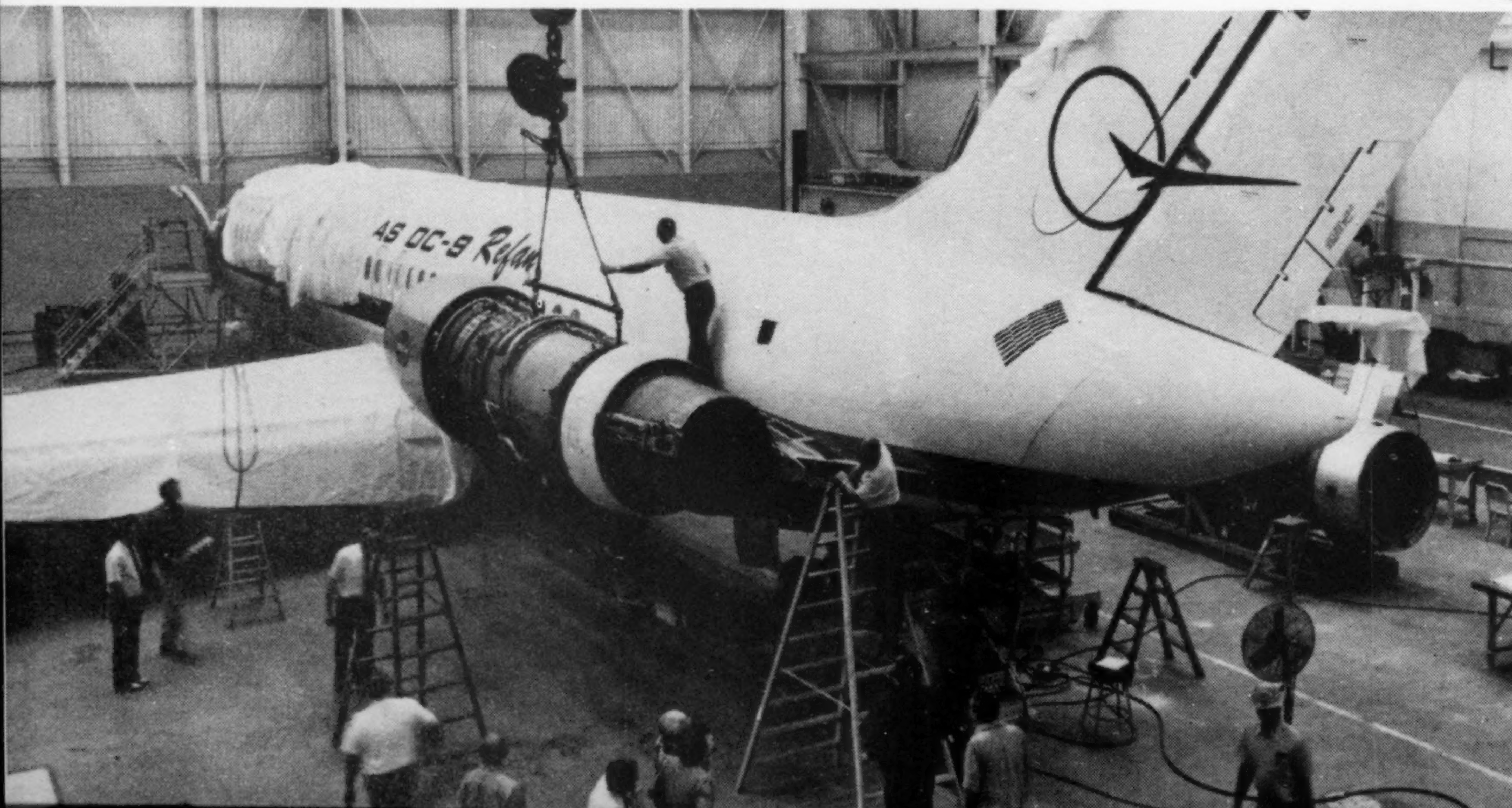


3. TURBOFAN

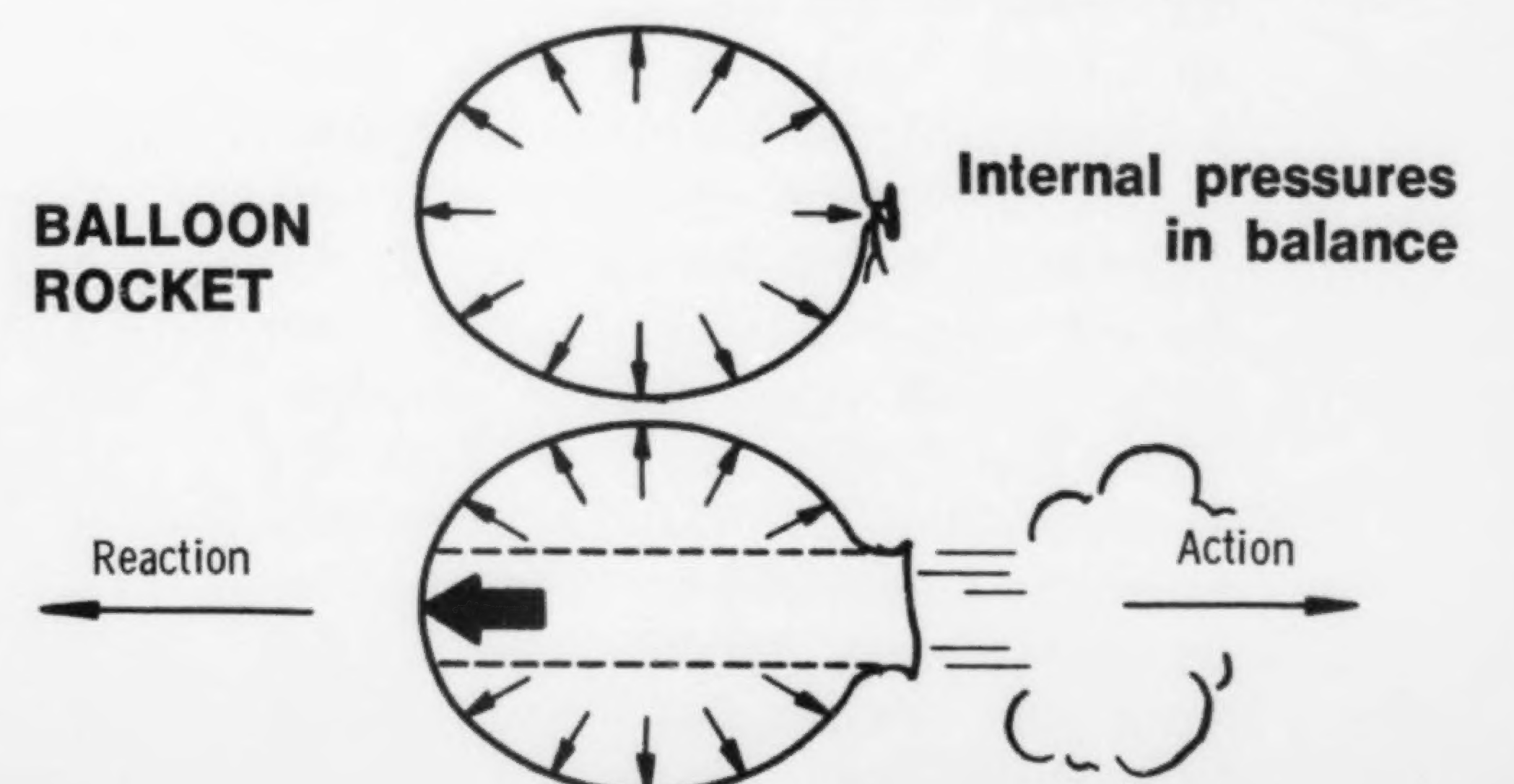
The casing around a large front fan ducts air outside as well as into compressors for greater thrust.



Below, technicians install a modified turbofan engine in a DC-9 at the McDonnell Douglas plant, Long Beach, California. Changes resulted in a quieter operation.

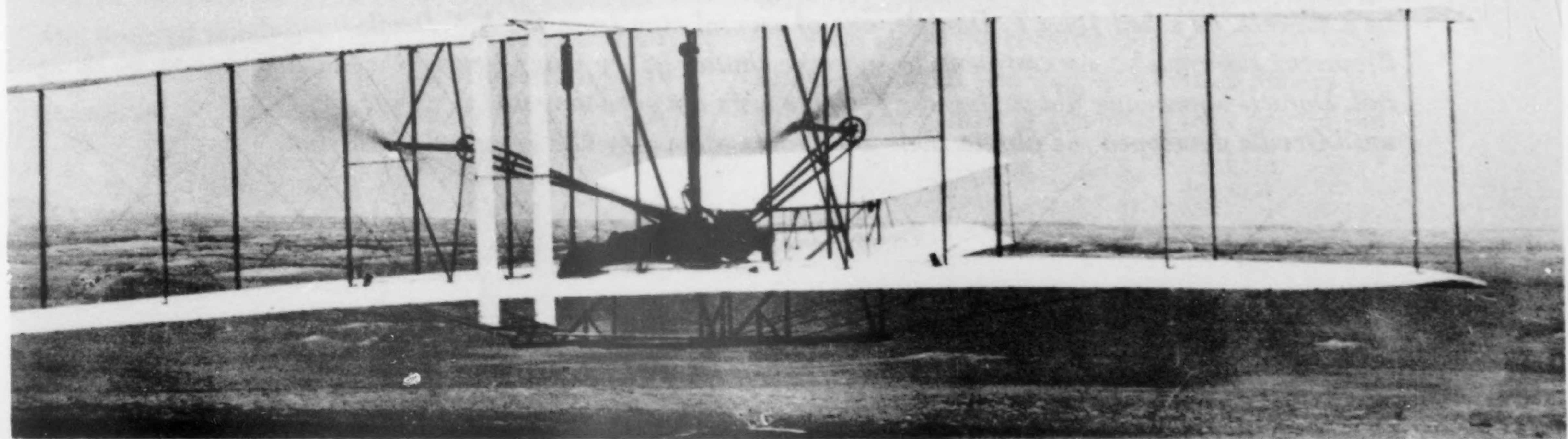


BALLOON ROCKET

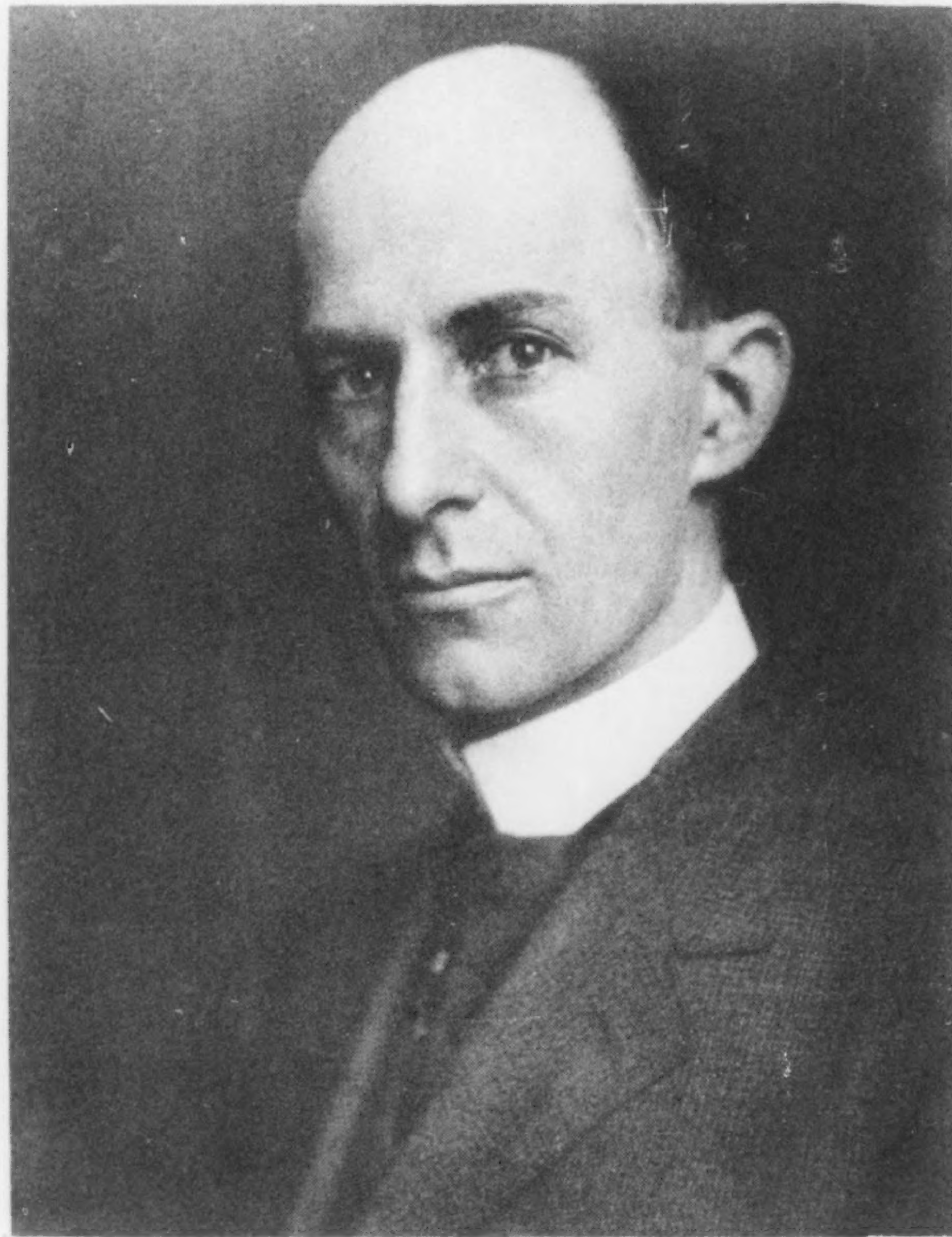


NATIONAL AIR AND SPACE MUSEUM SMITHSONIAN INSTITUTION WASHINGTON, D.C.

The Wright Brothers



Wilbur Wright



Orville Wright



Wilbur and Orville Wright achieved the first successful powered and controlled human flight in a heavier-than-air craft at Kitty Hawk, North Carolina, at 10:35 A.M. on 17 December 1903.

The Wright brothers conceived, designed, built, and flew the first airplane. Thus, they fulfilled man's ancient dream of flying, and opened the

Air Age. The Wrights also developed the airplane into a practical form, and taught others to fly.

Wilbur Wright was born near Millville, Indiana, on 16 April 1867. Orville was born at Dayton, Ohio, on 19 August 1871. They had two older brothers and a younger sister. Their father, the Reverend Milton Wright, was a bishop of the

The cover photograph *The historic photograph on the cover shows Orville Wright at the controls of the Wright Flyer as the first flight was made on 17 December 1903. After he and his brother Wilbur had set their plane on the launching track and had run up the engine, Orville arranged the camera on a tripod and focused it on a point a few feet short of the end of the track. Confident that the flight would be a success, he asked John T. Daniels, one of several men from the Kill Devil lifesaving station who were present, to snap the shutter as the plane cleared the starting rail. Daniels apparently did so, but the Wrights were not sure they had a picture until Orville developed the film in their dark room after they had returned to Dayton.*

United Brethren Church. Their mother was known as a well-informed, skillful, and resourceful woman.

Wilbur and Orville became interested in flying when they were boys living in Dayton. Their father brought home a small flying toy powered with rubber bands. They were fascinated by its ability to flutter about the room, and were introduced to the elements of aviation when they tried to repair it and make others. Orville became adept at building and flying kites. Later, the brothers read of experiments by Otto Lilienthal, a German scientist, who built and flew gliders. They were intrigued by the thought of riding on the air, and decided that they would take up gliding as a sport.

In the same period, news articles were being circulated about experiments in aerodynamics and with model aircraft conducted by Samuel P. Langley, third Secretary of the Smithsonian Institution. He built an unmanned steampowered "aerodrome" which flew successfully over the Potomac River in May 1896. The Wright brothers wrote to the Smithsonian in 1899 seeking further information. The Institution sent them pamphlets describing early experiments in flying and suggestions for further reading. They obtained other information from Octave Chanute, an engineer living in Chicago, who had built and tested gliders.

Building a Machine

The brothers operated a shop in Dayton where they built and repaired bicycles. There they constructed a glider-kite with which they tested their first ideas for support and control. To find the best location for their experiments, they sought information from the Weather Bureau, and decided that Kitty Hawk, a small community in North Carolina, might be well suited for their experiments. They corresponded with W. J. Tate

who lived there, and he told them of the large sand dunes and steady winds at that location, situated on a sandy stretch between Albemarle Sound and the Atlantic Ocean.

From the autumn of 1900 until they achieved successful flight in 1903, the Wrights worked intermittently at Kitty Hawk on their experiments. Their first large glider was assembled on the front porch of the Tate home. It was a biplane with a wing span of 17½ feet and 165 square feet of surface. They flew it unmanned as a kite, operating the controls with cords manipulated from the ground.

Based on this experience, the brothers built a larger glider upon their return to Dayton. They flew it in 1901 on their next vacation at Kitty Hawk. This glider had a span of 22 feet and an area of 290 square feet, and would support a pilot in winds of medium velocity. These tests gave them experience in operating their control system from on board the glider.

Some previous experimenters with gliders had tried to control steering, elevation, and balance by shifting the weight of their bodies or swinging their legs, but this was not efficient. The Wrights devised a means of control by manipulating the surfaces, and this improved system of "aileron control" eventually was patented by them.

The front elevator of their 1901 glider could be moved by a handle to control climb or descent. For lateral balance they twisted or warped the outer ends of the wings by means of inter-connecting wires. The 1901 glider did not always perform as expected, however, so they decided to gather their own mathematical data through experiments to determine the principles of aircraft design. Orville rigged up a small box and placed two different surfaces within it to study their relative action as air was blown through it. This test led to the construction of a larger wind tunnel about six feet long and sixteen inches square. The wind was generated by a pair of fan

blades, mounted on a grinder head, driven by a belt from the line shaft in their shop. They tested more than two hundred different shapes at many angles and in various relationships. This scientific laboratory work provided them with a reliable set of figures and tables from which they could design their next glider.

Their third glider had a span of 32 feet, but its surface area was not much greater than that of its predecessor because the wing was narrower. The new design had a vertical rear surface, and a better system of operating the wing-warping wires. In this system, the pilot's hips fit into a saddle, and he operated the wires by moving his hips, instead of pressing foot pedals.

As the summer bicycling season drew to a close in 1902, and the brothers could afford to take another vacation, they went to Kitty Hawk and tested their redesigned craft. It worked much better than the previous ones, but the lateral balance still did not always function properly. They finally traced this fault to the vertical keel at the rear, and they changed it from a fixed surface to a hinged rudder. To counteract the tendency of the low wing to drag, they combined the rudder action with the warping system so that a single movement by the pilot operated both. This proved to be a highly efficient method of control. It was incorporated in their later patent, and has been described as one of the greatest inventions in the history of air transportation.

By now, the Wrights had established firm principles of design, had developed efficient construction, and had become skillful in operating the controls of their aircraft. Back in Dayton, the Wrights built their next machine with the intention of powering it with an engine and propellers. Because they could not find an engine with suitable specifications, they built their own with the assistance of their ingenious mechanic, Charles Taylor. The four-cylinder engine, with a

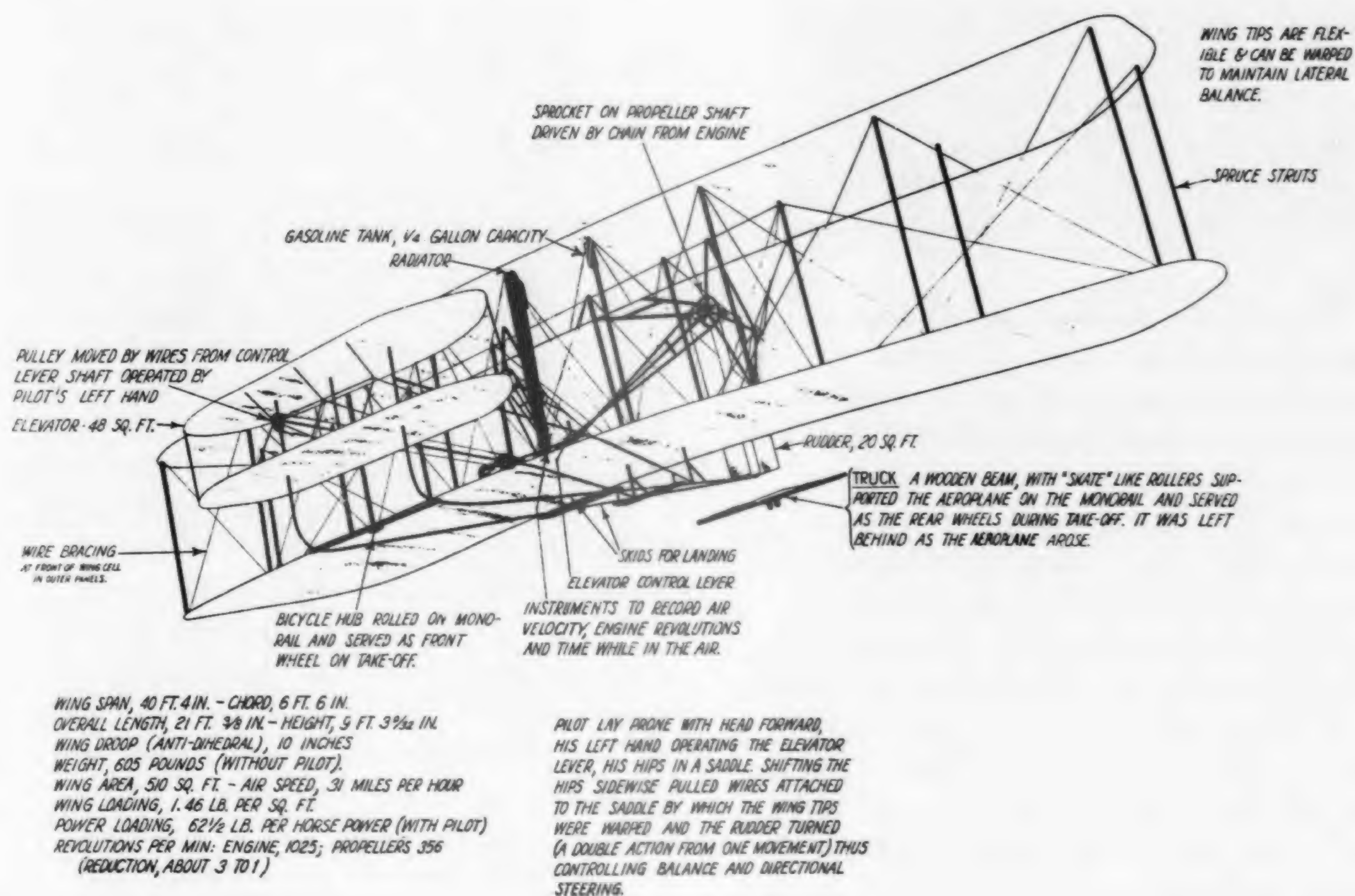
four-inch bore and a four-inch stroke, developed twelve horsepower. The cylinders were horizontal and in line, and the engine was watercooled. It had no carburetor. Instead, the gasoline was vaporized after dripping on a distribution plate that extended to cylinder ports. This was an elementary form of the fuel-injection system.

The First Flight

The craft was shipped to Kitty Hawk where it was finally made ready for flying by 14 December 1903. The day was calm, so the Wrights laid the launching rail on the lower slope of Kill Devil Hill, largest of the sand dunes at Kitty Hawk. The brothers tossed a coin to determine who would make the first flight. Wilbur won. He took his place at the controls, the engine was started, the restraining wire was released, and the craft rolled forward. It rose into the air, but Wilbur elevated the front control too high and the plane stalled and settled down awkwardly at the bottom of the slope 105 feet distant, after being in the air about three seconds. Several days were required for repairs.

On 17 December, the brothers were ready to try again. The day was cold and windy. The track was laid this time on the level sand about one hundred feet west of the double building which served the Wrights as living quarters and hangar. They knew that the high wind of about 30 miles an hour would add to the difficulty of controlling the aircraft, but that it would give added lift at take-off and would slow the landing speed.

It was Orville's turn. The engine was started and warmed up. Orville settled himself in a prone position, with his hips resting in the saddle and his feet braced against a foot rest. His left hand grasped the elevating lever, and his right arm supported his weight. His right hand was ready to shut off an engine-speed indicator, a stop watch, and a wind-speed meter as soon as the flight ended.



The Kitty Hawk Flyer This nomenclature drawing illustrates the parts and specifications of the world's first successful powered heavier-than-air craft to be controlled by man. First flown by Orville Wright on 17 December 1903 at Kitty Hawk, North Carolina, the flyer is an outstanding specimen in the National Aeronautical Collections.

With the propellers whirling, the restraining wire was released. The craft moved forward slowly. Wilbur, running alongside one wing tip, was able to keep up with it. It ran forty feet on the rail, and then rose into the air. Orville later recounted what man's first airplane flight was like:

The course of the flight up and down was exceedingly erratic, partly due to the irregularity of the air, and partly to lack of experience in handling this machine. The control of the front rudder was difficult on account of its being balanced too near the center. This gave a tendency to turn itself when started, so that it turned too far on one side and then too far on the other. As a result, the machine would rise suddenly to about ten feet, and then as suddenly dart for the ground. A sudden dart when a little over 100 feet from the end of the track, or a little over 120 feet from the point at which it rose into the air, ended the flight.

As the velocity of the wind was over 35 feet per second and the speed of the machine over the ground against the wind ten feet per second, the speed of the machine relative to the air was over 45 feet per second, and the length of the flight was equivalent to a flight of 540 feet made in calm air.

This flight lasted only 12 seconds, but it was nevertheless the first in the history of the world in which a machine carrying a man had raised itself by its own power into the air in full flight, had sailed forward without the reduction of speed, and had finally landed at a point as high as that from which it started.

Three more flights were made the same day. The longest, by Wilbur, was 852 feet in 59 seconds. While the Wrights and the five witnesses present were discussing their successes, a sudden and violent gust of wind upended the machine and damaged it severely.

Incidentally, the Wrights usually referred to their craft as their "flyer." The spelling "aeroplane" was generally used in the United States until World War I, when it was supplanted by the modern American spelling.

The Wright brothers continued to develop their invention in 1904. Since they no longer required the high winds and sand dunes of Kitty Hawk, they obtained permission to use a large field outside of Dayton known as Huffman's Prairie. There they practiced flying and improved their design and construction. On their fifty-first flight, in 1904, they bettered Wilbur's record for flight duration by two seconds. They made the first complete circle that year, and near the end of 1904 they made two five-minute flights, circling the field. A new machine built in 1905 was stronger and had other modifications, and flight distances and durations increased rapidly. By this time the flights were beginning to attract attention, and the brothers took steps to protect their invention. They also entered into correspondence with the United States government offering their invention for military use, but the government refused to believe that an actual flying machine existed. An early interest shown by the British government soon faded.

Meanwhile, other experimenters had been busy, and in 1906 Alberto Santos-Dumont, a Brazilian living in Paris, made the first flight in Europe. It lasted six seconds. When reports circulated that the Wrights had stayed aloft much longer, other experimenters were incredulous.

Public Demonstrations

To prove their ability, the Wrights arranged to make demonstrations. First they went back to Kitty Hawk to perfect several improvements. There they sat upright at the controls for the first time. Their seclusion was shattered by a group of reporters who had decided to investigate the reports of the Wrights' accomplishments. From

"ambush" they were astounded to see actual human flights. A resulting article in *Collier's* magazine made it even more imperative that the brothers give demonstrations.

Wilbur then went to France where he showed mastery of his machine by piloting it more than an hour at LeMans and Pau. He later made flights in Germany and Italy, some of which were witnessed by royalty. These resulted in the sale by the brothers of foreign manufacturing rights to their invention.

Orville brought his machine to Fort Myer, Virginia, across the Potomac River from the District of Columbia, to give demonstrations for government officials. In July 1909 he completed a series of tests to meet standards prescribed by the government as a prerequisite to its purchase of a Wright Flyer. The requirements included an hour-long flight with a passenger, a minimum speed of 40 miles an hour, the ability to carry fuel for a flight of 125 miles, and ease of disassembly for overland transportation of the craft. After the tests were completed, the Army Signal Corps paid \$25,000 for the plane, plus a bonus of \$5,000, since the craft had exceeded the minimum speed requirement by attaining 42.583 miles an hour.

By that time, the Wright brothers were being acclaimed for their mastery of the air, and were the recipients of many honors. The principles of aviation they had developed were used by other experimenters to bring about further developments. Air meets were organized and there was keen competition between pilots and types of planes. Distance flights were made from city to city and from country to country.

In France, Germany, and Italy the brothers instructed selected men in flying and maintaining the aircraft, in accordance with the agreements under which they sold their planes and patent rights. In this country, the army established a school at College Park, Maryland, where the Wrights taught many of the first military pilots.

A school for civilians was set up at Dayton, with winter flying at Montgomery, Alabama. To meet the public's demand to see a plane in flight, exhibition teams were organized. A team for the Wrights was organized by Roy Knabenshue, an experienced builder and operator of dirigibles. All of these activities increased the need for aircraft, and led to the formation of the Wright Company at Dayton.

Later Planes

The original design of the Wright Flyer was altered and improved as knowledge and experience advanced. In the Wright "B" the elevator was moved to the rear of the plane from its original location in the front, and wheels were attached to the skids. The "C" was intended for military use and had changes in its keel surfaces. The "R" was a racer which was smaller and had more power than its predecessors, but did not compete successfully because of an accident. The company also produced the type "G" flying boats, and float-mounted hydroplane adaptations designated type "H." Twenty-five types of aircraft were made by the Wrights and their associates from 1899 to 1922.

On 30 May 1912 Wilbur Wright died of typhoid fever. Orville became president of the Wright Company, continuing with the design and construction of aircraft. He worked also on a device for maintaining stability in flight. Although he preferred this type of activity, he was called on in this period to participate in a number of legal proceedings involving the Wright brothers' patents. It was not until 1914 that the principal suit was settled, and he was able to turn over the business details to others.

Orville continued to maintain his eminent position in aeronautics. In World War I he was an official of the Dayton Wright Company which manufactured thousands of airplanes. After the war he served on many groups dedicated to

advancements in flight, including the National Advisory Committee for Aeronautics. On 30 January 1948 he died at Dayton.

The three most historic Wright aircraft are in the National Aeronautical Collections exhibited by the National Air and Space Museum, a bureau of the Smithsonian Institution. The museum also possesses models of Wright planes, other memorabilia pertaining to the Wright brothers, and some of their early equipment.

The Wright Military Flyer (type "A") was placed in the collections in 1911, after two years in active service with the signal corps. It was the first military airplane, and in it many of the nation's first flying officers earned their wings. It established world records for duration of flight, and was in its day the outstanding aircraft in the world. It was used to develop many of the army's elementary air tactics. It is now displayed in the Arts and Industries Building at the Smithsonian, pending construction of an Air and Space Museum.

The first plane to be flown across the United States was built by the Wrights, and is on display in the temporary Air and Space Museum Building at the Smithsonian. This craft, the *Vin Fiz*, is a Wright Brothers Type "EX" plane. The transcontinental flight was made by Calbraith Perry Rodgers in 1911. He flew from Sheepshead Bay, Long Island, to Long Beach, California, in 84 days, making 70 landings. Some of the "landings" were severe crackups. The plane was repaired so many times that the only original parts to survive are the rudder and one strut. Rodgers had to hobble from the craft on crutches at the end of the flight. The plane—named for a soft drink that it advertised—was brought to the Institution in 1934 and has been authentically reconditioned.

The original Kitty Hawk Flyer of 1903 was boxed and returned to Dayton after the first series of flights. It was repaired and reassembled in 1916 for display at the Massachusetts

Institute of Technology. It was shown in several air shows, and in 1928 was loaned to the science museum at South Kensington, London, England, where it was on display for twenty years. It was formally installed at the Smithsonian on 17 December 1948, the forty-fifth anniversary of the first flight. It was suspended inside the entrance to the Smithsonian's Arts and Industries Building. With the opening of the new National Air and Space Museum on July 1, 1976, the *Kitty Hawk Flyer* took its place in the center of the Milestones of Flight Gallery to permanently commemorate the brothers who opened the Air Age.

The National Air and Space Museum can supply a selection of photographs of the Wright brothers and their machines. Before ordering, please request a price list from the National Air and Space Museum, Smithsonian Institution, Washington, D.C. 20560. Available photographs and their negative numbers, which must be used in ordering, follow:

The Wright brothers' glider of 1900

A38530-L

The Wright brothers' glider of 1901

A41898-I

The Wright brothers' wind tunnel

(reproduction) A41020

The Wright brothers' glider of 1902

A38530-M

The Kitty Hawk Flyer of 1903 making its first flight (cover photo) A26767-B

The 1903 flyer as now exhibited A38391

Portrait of Orville Wright A32497

Portrait of Wilbur Wright A32497A

The Wright Military Flyer of 1909 A30959-E

The Wright brothers' transcontinental flyer Vin Fiz, 1911 A31809-A

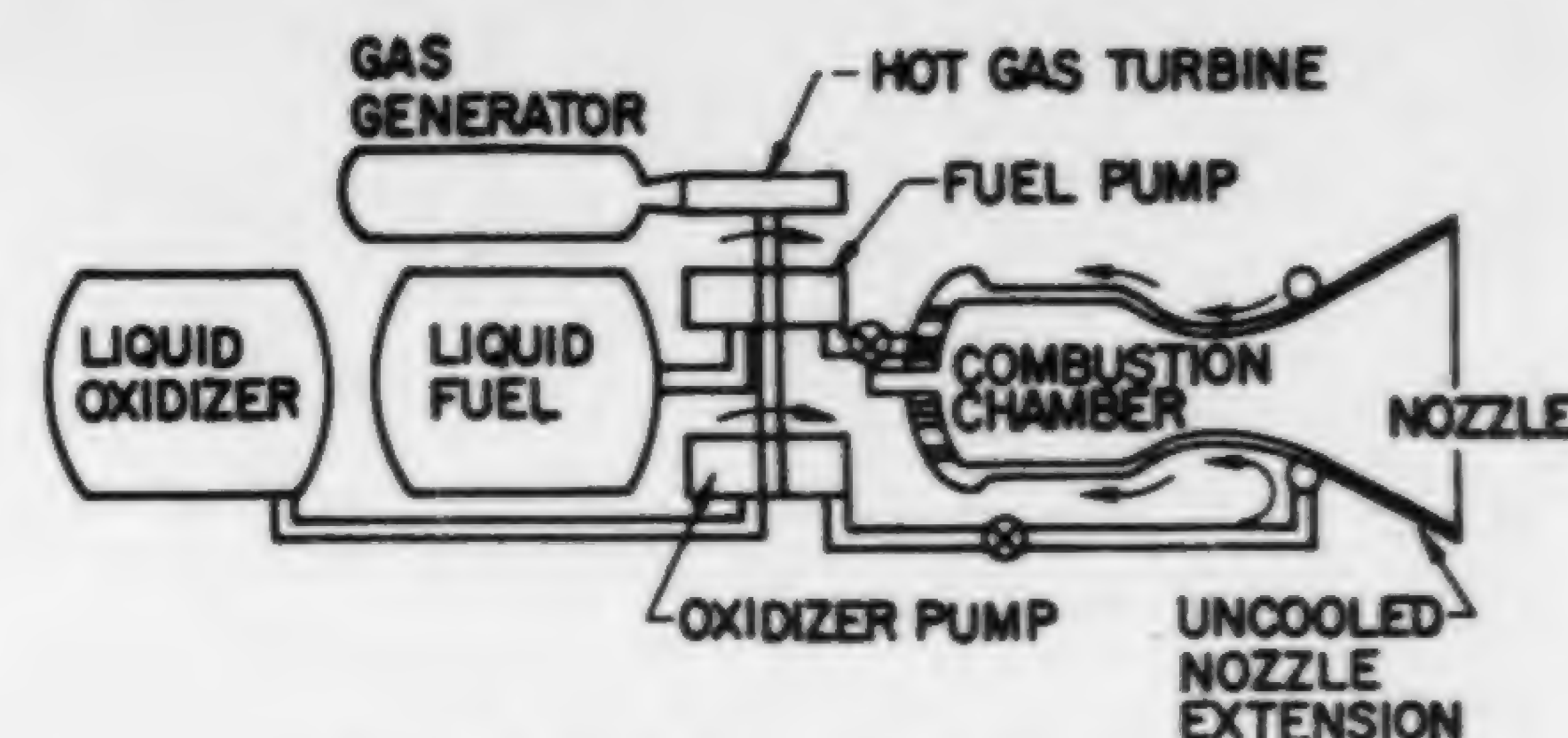
Nomenclature drawing of Kitty Hawk Flyer
A38681

GPO 914-612

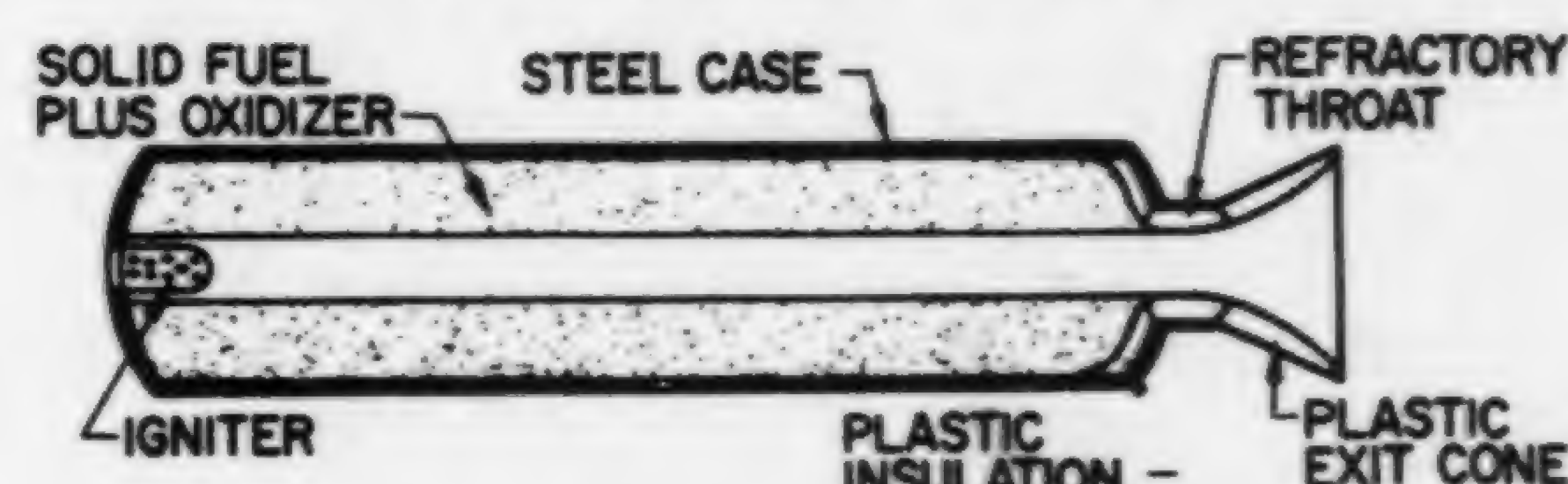


ENGINES FOR LEAVING EARTH

Two types of engines diagrammed right do the toughest jobs ever required of any propulsive system, lifting enormous weights straight up, at first (photograph to the left). On the pad, Apollo 11, for instance, weighed 2,941,220 kilograms. The more reactive and efficient the chemical propellants, the more dangerous they are to manage. Some day, the burning of chemicals may seem only a first step in learning how to battle gravity and reach space.



Liquid-propellant rocket motor



Solid-propellant rocket motor

Top: One layout for a liquid propellant engine. Before fuel and oxidizer arrive at the combustion chamber, they are pump-driven through hollow walls of that chamber to serve as coolants. Otherwise, combustion heat which can reach 3,316°C (6,000°F) would melt the materials in the chamber. **Lower diagram:** One layout for a solid mix of fuel and oxidizer which burns from the center out.

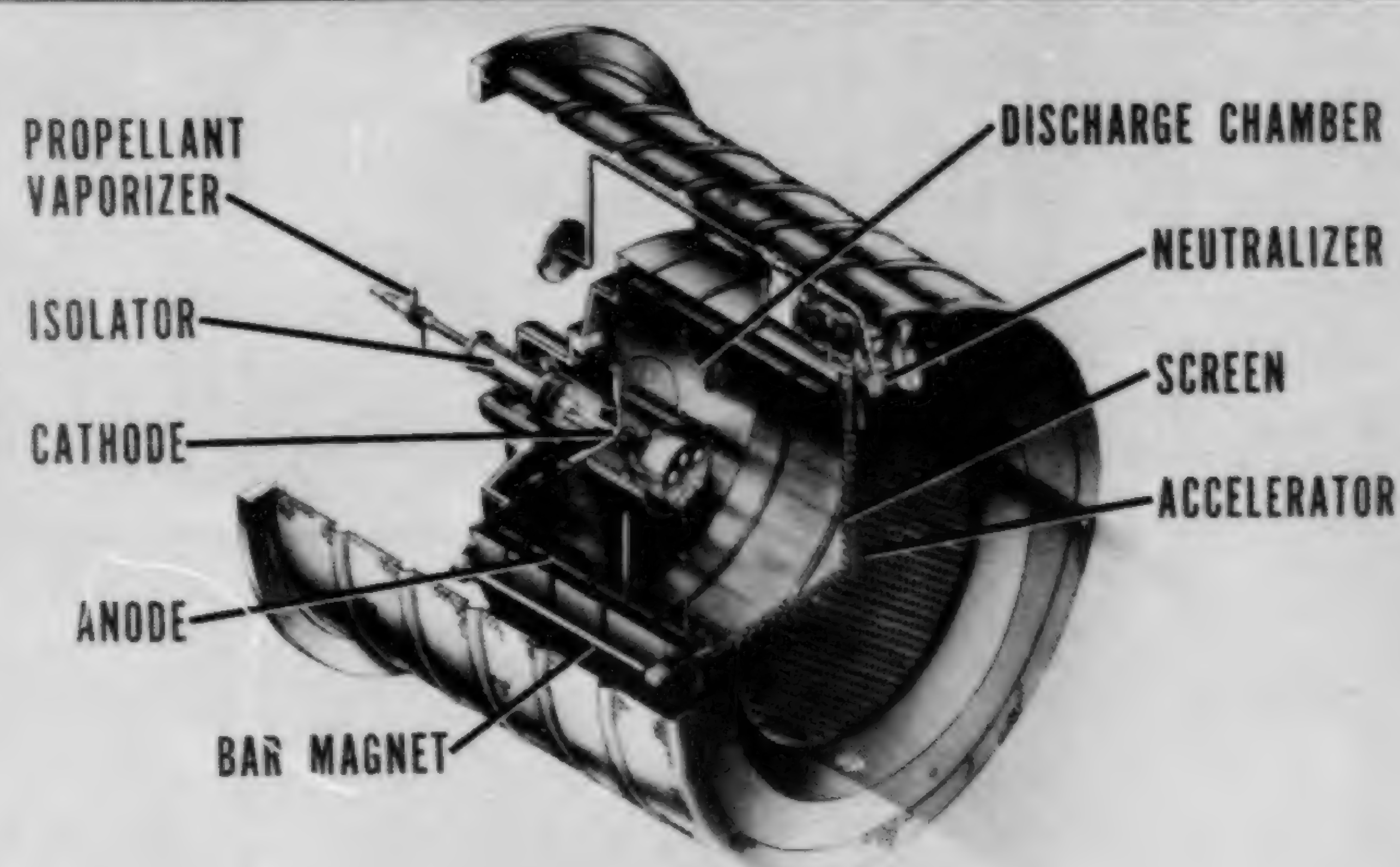
ENGINES FOR USE IN SPACE

Launches require brute strength but propulsion in space is best with low, sustained thrust. Among novel engines is SERT II below (Space Electric Rocket Test). It exhausts ions, and has remained efficient in space since its launch in 1970.

Below: The ion engine in SERT II, useable only in space. The propellant is a vaporized gas, ionized by electron bombardment in the discharge chamber. (Mercury or cesium gas is preferred; these ionize easily.) An electric field between screen and accelerator attracts the ions and accelerates them through the screen at velocities ranging from 20 to 50 kilometers/second. Then electrons are restored to make the exhaust electrically neutral. In space, this electric engine is 8 to 10 times more efficient than chemical propulsion.



ELECTRON-BOMBARDMENT THRUSTER



CHEMICAL PROPULSION

Other methods of propulsion will work better

ENGINES USED ENTIRELY OR PARTIALLY IN THE ATMOSPHERE

USED IN SPACE ONLY

Engine	Reciprocating engines	Reaction engines: Ejection of Mass = Reaction of forward thrust	
Vehicle	Piston-propeller aircraft	Jet aircraft	Launch vehicle
Propellant	Satellites and spacecraft		
	Oxygen in air (21%) as oxidizer; petroleum base fuels		
Operation	Pistons produce many small power strokes, turning a crankshaft that turns propeller(s). Both work on 4-stage cycle: 1. Intake of air 2. Compression of air 3. Combustion 4. Exhaust Power is transferred by moving parts.	Entire structure of engine reacts to exhaust and provides forward thrust continuously. Power is transferred with no moving parts.	Potent oxidizers must be carried internally. Solid propellant combines oxidizer and fuel in a hard substance. Greater specific impulse comes from liquids, such as liquid oxygen at -183°C (-297°F) as oxidizer, with liquid hydrogen at -253°C as fuel. These and other exotic chemicals give raging thrust but are hazardous to manage. The entire rocket reacts to the exhaust. No single stage rocket can yet lift payloads to orbit; thrust is increased by stacking 2 or 3; by clustering engines inside the airframe; or by strapping on extras outside. Acceleration increases rapidly as air friction and gravitational pull diminish, as the propellants vanish (Saturn V Stage 1 burns some 534,000 gal. in about $2\frac{1}{2}$ min.), and as stages are jettisoned. Power plants eject the chosen mass at high speed. Electromagnetic ejection for powder or pellets has been demonstrated. An electric field accelerates ions in space-tested electric engines.
Source of thrust	Thrust: The forward lift generated by whirling propeller blades.	Hot gases of chemical combustion are the usual ejected mass, providing reaction thrust. The faster the gas exhaust, the greater the mass and reaction (thrust). Nozzles accelerate gases to supersonic speeds.	
Measure of efficiency	Horsepower: A unit of power in the U.S. Customary System equal to 745.7 watts or 33,000 foot-pounds of work per minute.	Thrust, per Newton's Second Law; Force = mass $\times$ acceleration.	Specific Impulse (I_{sp}): Kilograms (or pounds) of thrust for each kilogram (or lb) of propellant burned in 1 second; expressed in seconds. Kerosene/liquid oxygen rated 250-300 sec.; liquid hydrogen/liquid oxygen rated 450 sec. Goal for chemicals: 600 sec.
Speeds	Propeller-driven planes are limited to approximately 724 km/hr (450 mph); efficient cruise speeds are around 483 km/hr.	Commercial subsonic jets cruise efficiently at about 875 km/hr at 10 to 11 km altitude. Supersonic Concorde cruises at Mach 2 (twice the speed of sound which differs according to altitude).	I_{sp}. In space, low exhaust mass and low thrust can give enormous specific impulse. Solar energy and hot gas exhaust give 450 sec.; electric/ion, 1,000-50,000 sec.; nuclear/hot gas, 600,000-1,000,000 sec. Speed in space is hard to comprehend—tens of thousands of kilometers per hour. Pioneer 11, without mechanical help, using Jupiter's gravity, accelerated to 171,000 km/hr (106,000 mph).

In December — News from Venus

December 4—the first Pioneer Venus spacecraft, which left Earth May 20, swings close to bright, cloud-wrapped Venus, Earth's nearest sibling on the Sun-side. December 9—the second Pioneer zooms in. . . if all went well; launch was scheduled for August 7, after this publication went to press.

What happens then is pictured by an artist on the back cover.

The Soviets may be sending their twelfth mission to Venus during the same August "launch window" (period when the feasible trajectory will intersect the target). Some Soviet craft have achieved landings, whereas the four earlier U.S. flybys have studied the strange atmosphere which may hold lessons for Earthlings.

Named for the Roman goddess of love, Venus is a devastating temptress. She was formed at the same time as all other planets, some 4.5 billion years ago. Her vital measurements and body density are similar to Earth's, but her environment is now lethal and her behavior baffling.

Figures in the box below show the startling contrasts—carbon dioxide atmosphere, pressure 90 times Earth's, and heat which would melt tin and lead. Venus rotates "backward" (the Sun rises in the west) and so slowly that the time from one sunrise to another is 245 Earth-days long, longer than the Venusian year. Yet winds blow the top layer of clouds in the direction of rotation at 360 kilometers per hour (220 mph; Earth's worst hurricanes may reach 150 mph). These clouds circle Venus in only four Earth-days. Why? Why? Why?

The Pioneer mission concentrates on Venusian weather, which is virtually the same, all the time, everywhere. Understanding that simpler "weather machine" may give meteorologists clues about basic principles to help unravel the mysteries of Earth's very complex weather, and the large patterns called climate. Environmentalists wonder if all the CO₂ being spewed into Earth's atmosphere could bring on a Venus-type "greenhouse effect" where incoming solar heat is trapped, and not radiated away.

Hear news of the Pioneer Venus mission at any time by dialing a special number at NASA's Ames Research Center: 415/968-5600. The recorded message is continually updated by the staff there.

Free Literature

NASA Press Kit, Pioneer Venus 2, 118 pp., diagrams. Comprehensive historical, scientific, technological information on Venus and the mission; 500 copies available through *Air & Space*. Write to Room 3569 (Museum address on back cover).

The Planet Venus, NASA Facts No. 86, 9 pp., illus., bibliography, class exercises. From NASA's regional education centers; write for list to NASA Headquarters, Code LFG-13, Washington, DC 20546.

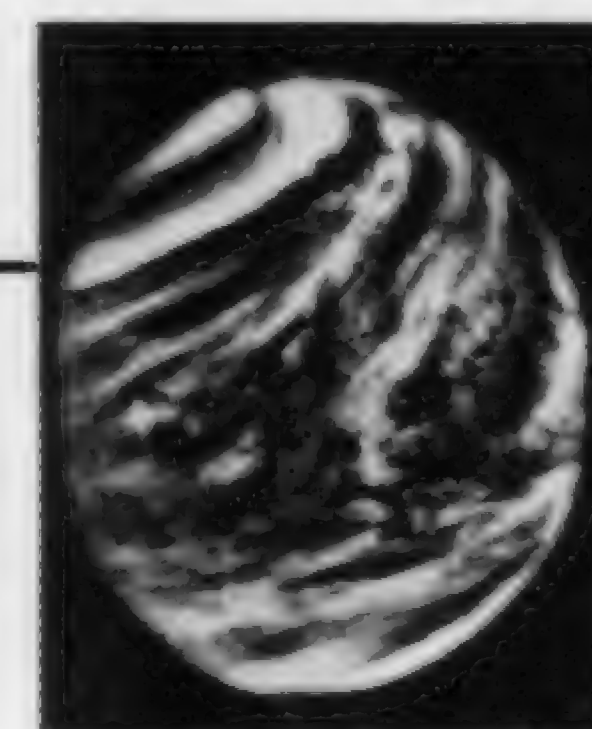
Pioneer Venus Mission Profiles 1978, 12 pp., illus. From Bendix Field Engineering Corp., Advanced Data Systems, 155-B Moffett Park Dr., Sunnyvale, California 94086.

Above: Pioneer Venus 1 (orbiter) with its streamlined casing (fairing) at Kennedy Space Center, Florida, last May. Below: Project manager Charles Hall of Ames Research Center with Pioneer Venus 2 (multiprobe). The carrier, called the "bus," is 2.4 meters (8 ft) in diameter, and coated with solar cells. Probe caps are of carbon phenolic for heat resistance. Crinkly covering is the 15th layer of insulating aluminized Kapton.

EARTH



VENUS



Mean distance from Sun	149.6 million km	108.2 million km
Mass	1.	.815
Equatorial diameter	12,756. km	12,104. km
Gravity	1.	0.88
Rotation (day)	23 hr/56 min/4 sec	Once every 243 days retrograde
Revolution (year)	365¼ days	225 days
Atmosphere	21% oxygen 78% nitrogen, etc.	Carbon dioxide
Atmospheric Pressure	1,000 millibars	90,000 millibars
Clouds	Water vapor; about 50% of the time over 50% of area	Sulphuric acid in water solution; al- ways total cover
Surface temperature	Varying	482°C. (755°K, 900°F.) always, everywhere

Farthest-Out Adventurers

Christopher Columbus' home town, Genoa, Italy, awards a gold medal every year for "preeminence in courage, keenness and acuteness in research studies and achievements, audacity of realizations, tests of highly human significance, effective contribution to scientific advancement and dissemination of information thereof."

Last fall, the Columbus Gold Medal went to NASA's Ames Research Center, Moffett Field, California, for management of the two spacecraft which opened the era of exploration of the outer planets: Pioneer 10 and Pioneer 11. These are now the farthest-from-Earth explorers of all time.

Launched March 2, 1972, Pioneer 10 carries 13 scientific sensors, and in 1973 sent back the first actual readings of Jupiter's violent environment and more than 300 close-up "photographs." It crossed the orbit of Saturn in February, 1976; will reach the orbit of Uranus in 1979, of Pluto in 1987; and then will become the first object made

on planet Earth to leave the Solar System.

Pioneer 11, launched April 5, 1973, passed even closer to Jupiter and returned the first pictures of its polar regions. Jupiter's gravity accelerated the little craft to the highest speed ever attained by a manufactured object: 171,000 kilometers per hour (106,000 mph). Pioneer 11 will encounter Saturn in September, 1979, and eventually leave the Solar System.

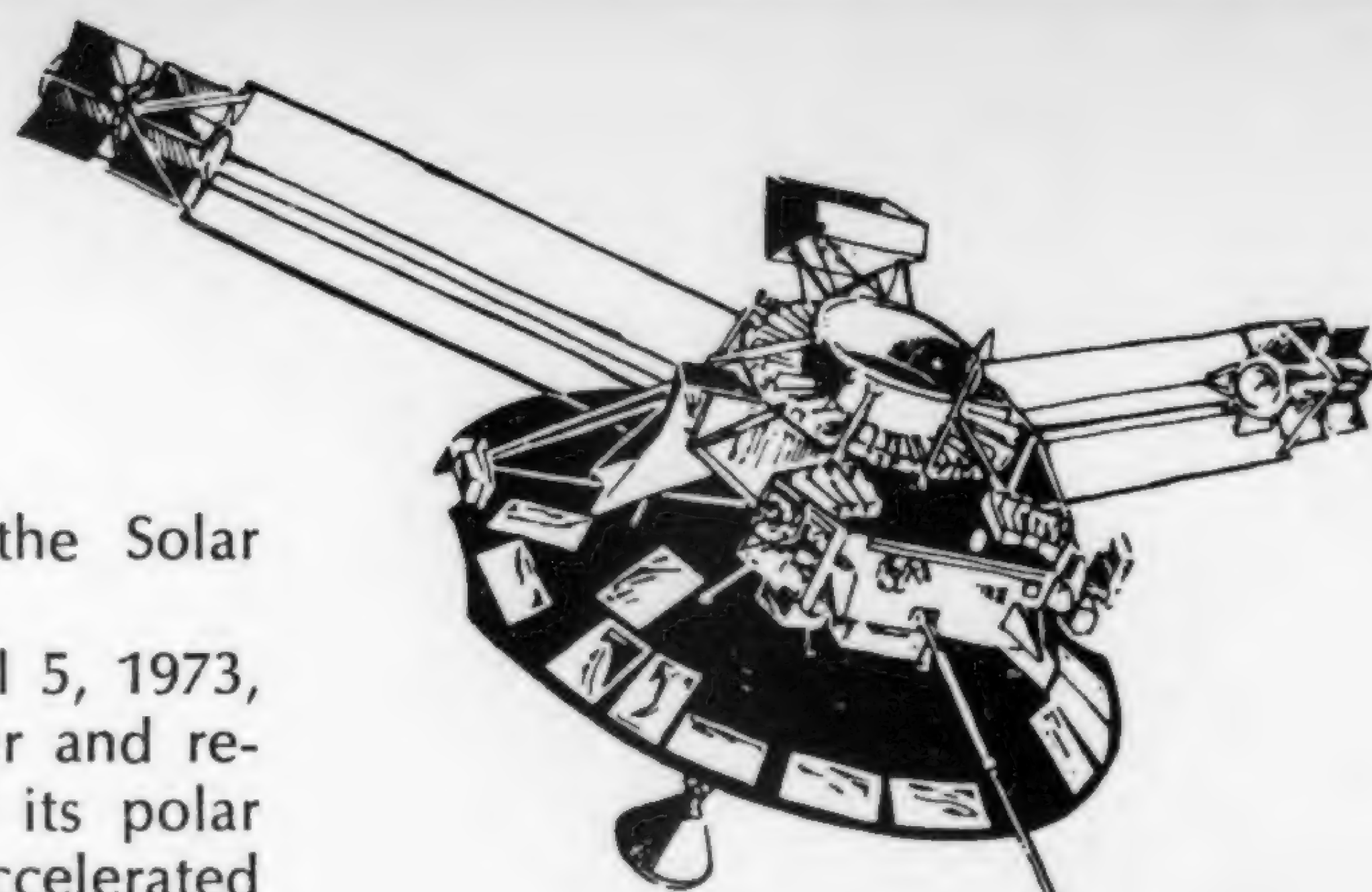
The next pair of outer planet explorers, called Voyager 1 and 2, left Earth August 20 and September 5, 1977. The first will encounter Jupiter in March of 1979, the second in July of 1979.

Jupiter is so far away that radio messages moving at the speed of light take 45 minutes for a one-way trip.

The highest transmission power on the Voyagers is 28 watts. Everyone knows how much light comes from a 30-watt light bulb. NASA's Deep Space Network tracking such missions has

to lock onto a signal no more powerful than that, being radiated from a typical distance of 643 million kilometers (400 million miles). Moreover, the signal is competing with Jupiter's own powerful radio emissions and much static from charged particles in interplanetary space.

"The signal isn't so hard to pick up," says Alan S. Wood of Jet Propulsion Laboratory, Pasadena, California. JPL operates NASA's deep space tracking and data acquisition network. "But amplifying and unscrambling the data is an awesome job. It's only possible because the maser amplifiers are cooled to practically absolute zero to eliminate resistance."



OSCAR station, Washington Township High School, Sewell, New Jersey. Physics-astronomy instructor Herbert J. Lapp, Jr. and students tune in (far left) and adjust antenna. Mr. Lapp received a \$1,000 grant from the N.J. State Department of Education for OSCAR experiments, and began talking through OSCARs 7 and 8 last spring. Mr. Lapp is teaching in England this year but left a project summary available on request to Frank Gray at the school, Hurffville-Cross Keys Rd., RFD 3, Sewell, New Jersey 08080.

Satellite Textbook for the Asking

For new readers of *Air & Space*: The following summarizes a story in the April issue on educators' use of OSCAR, the communications satellite put up by amateur radio "hams."

A textbook, *Using Satellites in the Classroom, a Guide for Science Educators*, is available at no cost on request to *Air & Space*. Written by Dr. Martin R. Davidoff of Catonsville Community College, Maryland, the book was funded by the National Science Foundation for distribution to universities. This Museum acquired an overrun to share with high schools; many already operate receiving or transmitting-and-

receiving stations.

The book is paperback, 8½ by 11 in., typescript, illustrated, with glossary, references, data on satellite systems and tracking. Specific classroom work covers use of signals for study of Doppler shift, energy flow in space, the solar constant, auroral effects, etc.

For ample information on starting an OSCAR program, and finding local radio "hams" to help set up a station, educators write to Steve Place, Director, Office of OSCAR Educational Program Management, American Radio Relay League, 225 Main St., Newington, Connecticut 06111. Help is free.

\$500 for Space Essay

Entries in the Robert H. Goddard Historical Essay Award competition, open to anyone, are due November 1, 1978, at the office of the sponsor, the National Space Club. Honors include a \$500 prize. Essays (not over 5,000 words) should treat significant aspects of the historical development of rocketry and astronautics and are judged for originality and scholarship, according to the chairman of the Club's historical committee, Dr. Eugene M. Emme, recently retired NASA historian. For details, write to the National Space Club, 1629 K St. NW, Washington, DC 20006.



OUTREACH

by Kerry M. Joels

Chief, Education Division

Since the last school year, the Museum has formed a new, major Division for Education, and we plan this publication as one outreach to you.

Human progress in the areas of air and spaceflight underscores the anthropological aspect—the human ability to handle abstract ideas and create tools. Aerospace development is essentially a human process, and it is the humanity of that process which we will try to convey along with a lucid description of the concepts and thought processes.

The history of air and spaceflight is one of competition, insight, intuition, determination, bravado, serendipity and love—all distinctly human qualities. These have produced a considerable body of knowledge and a considerable technology. We educators and aware citizens need to con-

vey this to our fellows as a part of the heritage we share. Our features and news items will continue to provide information, supplemental curricular suggestions and activities, and important insights into the past, present and future of aeronautical and astronautical development.

The Smithsonian Institution, by virtue of its mission, is a unique source for a publication of this type. Many of the people here have not only documented and preserved the history of aviation and space, but have had a hand in the creation of that history. We hope that you will not only benefit from that expertise, but that it will lead to feedback from you regarding things you want to know more about, or ideas you have for dissemination or teaching the materials that have been

presented. *Air & Space* is your magazine.

As we progress through the year, this column will focus upon key educational "windows of opportunity." This issue is simultaneous with the 20th anniversary of the creation of NASA (October 1, 1958). Educators who have been writing "Behavioral Objectives" and "Learning Objectives" and who are familiar with "Conceptual Schemes" and all the science curricula of the 1960, owe these developments and stimuli to the impetus received by education to meet the demands of the national scientific and technological programs. Education was just one of the beneficiaries of the Appollo effort. Business management, organizational planning, technology, even our cultural perceptions of ourselves, changed as a result of the technological *tour de force* that has become our national aeronautics and space program. We hope to help you translate these programs and their meanings into classroom experiences.

Best wishes for a successful school year.

On the Wrights . . . Flights . . . Skylab

Wrights to wide-bodies: the first 75 years, Robert J. Serling, 8½ by 11 in., 8 pp., illus. from Air Transport Association of America, 1709 New York Ave., NW, Washington, DC 20006, free.

Poster, *The Wright Brothers*, 24 by 36 in., detailed drawing of first Flyer, information text, \$5.50 including postage, from NASM Room p701.

Films to borrow at no cost except return postage: Five, black-and-white, each 28 min., Paul E. Garber on *History of Flight—Wright Brothers*. Get Order Form from Federal Aviation Administration Film Library, AAC-44D2, Aeronautical Center, P.O. Box 25082, Oklahoma City, Oklahoma 73125. Code numbers: FAN 105, Part I; FAN 106, Part II; FAN 107, Part III; FAN 108, Part IV; FAN 109, Part V.

Also: *From Kitty Hawk to Aerospace*, 21 min., color, SFP 1240; and *Kites to Capsules*, 58 min., black-and-white, FA 905.

The Library of Congress will send photocopies of papers in the Wilbur and Orville Wright collection at 30¢ per page. A 22-page Register, with interesting preface, is sent free by the Manuscript Division of the Library, Washington, DC 20540. Even a few

letters or diary entries, selected from the Register, would give students a sense of the Wrights' personalities.

Color films by the Shell Oil Company lent at no cost except return postage: *How an Airplane Flies*. Four films on two reels, 56 min. *High Speed Flight*, 20 min. *Frontiers of Friction*, 18 min. (special lubrication of spacecraft). *Acting in Turn*, 19 min. (development of gear wheel). Shell Film Library, 1433 Sadlier Circle W. Dr., Indianapolis, Indiana 46239.

Aerospace Propulsion, newsletter, published on alternate Mondays, 25 times annually. Kimberly Communications Corp., 1067 National Press Building, Washington, DC 20045. \$115 annually.

Biomedical Results from Skylab, Richard S. Johnson and L. F. Dietlein, Eds. 11½ by 9 in., 491 pp., illus., diagrams in 40 scientific papers on physiological reactions to prolonged weightlessness. NASA SP-377, Government Printing Office, Washington, DC 20402, Stock No. 033-000-00648-9, \$10.50.

Proceedings, Skylab Life Sciences Symposium, August 1974, Johnson Space Center, NASA TMX-58154, 2 volumes,

paperback, 8½ by 11 in., total 862 pp., illus. N-75-14358/LLC at National Technical Information Service, 5285 Port Royal Road, Springfield, Virginia 22161, \$14 each volume.

A House in Space, Henry S. F. Cooper, Jr., paperback, 192 pp., illus. Bantam Books, New York, \$1.95. An account of life aboard Skylab.

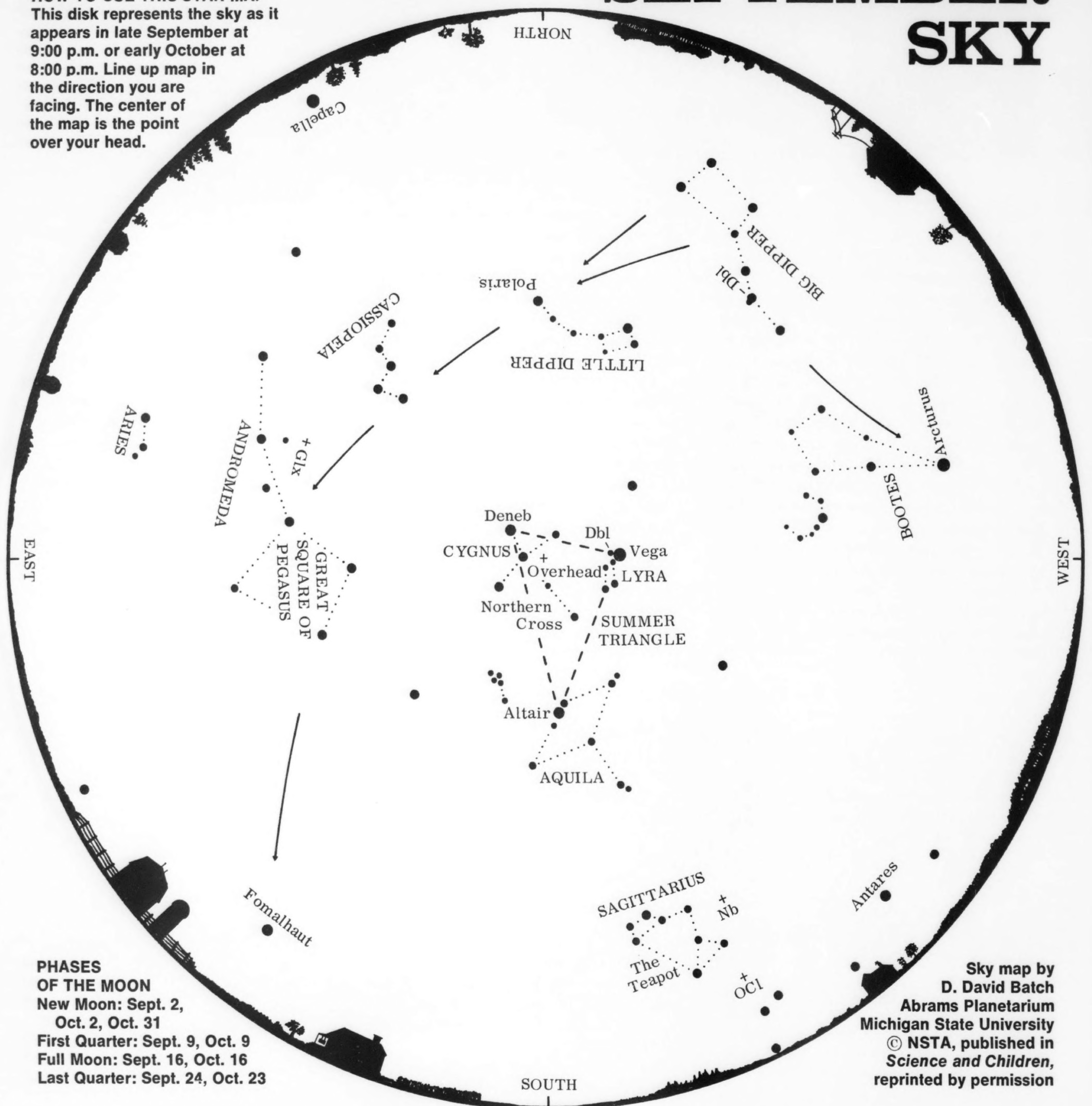
Skylab, Our First Space Station, Leland F. Belew, Ed., 9 by 12 in., 164 pp., lavish color illus., index. Government Printing Office, Washington, DC 20402, 1977, NASA SP-400, Stock No. 033-000-00670-5, \$7.

Skylab, Leland F. Belew and Ernest Stuhlinger, NASA Marshall Space Flight Center, paperback, 5½ by 9 in., 245 pp., illus., list of experiments, bibliography, glossary. Government Printing Office, Washington, DC 20402, 1973. Stock No. 033-000-00508-3, \$2.20.

Biology in Zero-G, Pamphlet No. 7 in series of 9 sold. as a set on *Apollo-Soyuz*. Paperback, 8 by 10½ in., 30 to 76 pp. each, color illus., many teaching aids. Government Printing Office, Washington, DC 20402, 1977, correct Stock No. 033-000-00688-8, \$10 the set.

SEPTEMBER SKY

HOW TO USE THIS STAR MAP
This disk represents the sky as it appears in late September at 9:00 p.m. or early October at 8:00 p.m. Line up map in the direction you are facing. The center of the map is the point over your head.



PHASES OF THE MOON
New Moon: Sept. 2,
Oct. 2, Oct. 31
First Quarter: Sept. 9, Oct. 9
Full Moon: Sept. 16, Oct. 16
Last Quarter: Sept. 24, Oct. 23

Sky map by
D. David Batch
Abrams Planetarium
Michigan State University
© NSTA, published in
Science and Children,
reprinted by permission

by **Dennis L. Mammana**
Staff Astronomer
Flandrau Planetarium, Tucson, Arizona

The major attraction of the evening sky this autumn is the brilliant planet Venus shining like a beacon over the southwestern horizon at sunset. By late October, however, Venus will be too close to the Sun for east observation and will leave the early evening sky with no visible planets.

Three very bright stars high in the west—Deneb, Vega and Altair—mark the three prominent constellations Cygnus the Swan, Lyra the harp and Aquila the eagle. Connected with imaginary lines,

the three stars form the Summer Triangle through which the hazy band of the Milky Way may be seen to stretch from north to south on a clear dark night.

Another geometric shape appears high in the east: the Great Square of Pegasus. On a clear dark night, far from city lights, you might be able to see a faint hazy patch of light midway between the Square and the constellation Cassiopeia. This is the farthest object visible to unaided eyes—the Andromeda Galaxy. It is so distant that the light we see originated in that galaxy more than two million years ago. Though it looks like only a hazy patch, it is a collection of hundreds of billions of stars, and is similar to the Milky Way

Galaxy of which we are a part.

Night owls and insomniacs may be the only ones to see October's Orionid meteor shower. On the mornings of October 21 and 22, the Earth will intercept a swarm of small meteoroid particles in space. Early risers who look toward the northeastern sky in the wee hours of those mornings may see some falling into our atmosphere, and glowing as "shooting stars." About 25 meteors per hour should appear to radiate from a point in the constellation Orion in the northeastern part of the sky. The last quarter Moon will be bright on those mornings and may decrease the number of meteors you can see.



P-40



XP-75

FAMOUS AND OBSCURE PLANES, NO. 4

by **Walter J. Boyne**
Curator of Aeronautics
National Air & Space Museum

Timing and good fortune are often critical in determining the fame of an aircraft. Consider the Curtiss P-40 "Warhawk" and the Fisher XP-75 "Eagle," both designed by Donovan R. Berlin. One achieved immortality as the shark-toothed fighter of the Flying Tigers, while the other, a much more sophisticated airplane, is forgotten today.

CURTISS P-40 "WARHAWK"

When World War II began in 1939, the P-40 was the best U.S. fighter available, and the only one in large scale production. However, it lacked the performance, maneuverability, fire power and armor of its European counterparts.

The key word, though, was "available," and large orders from the Allies poured in as well as a continuous stream of suggestions for improvement.

As a result, the P-40 became a competent, dependable warplane which, when flown by a good pilot using

proper tactics, was able to hold its own on almost any battle front. It served ably in Africa, Russia, Alaska, the Middle East and the Asian theater, but gained its greatest fame with the American Volunteer Group (AVG), the Flying Tigers.

More than 14,000 P-40s were built, and several are still flying today. An especially handsome example is on exhibit at NASM's suburban Silver Hill Museum.

XP-75 "EAGLE"

When Don Berlin joined the Fisher Body Company in 1942, the U.S. Army Air Force was demanding a new long range fighter. Berlin proposed to save time and money by using parts from existing production aircraft—the tail of a Douglas SBD, wing panels from the P-40, landing gear from a Corsair, etc.—and marry them to the powerful new Allison V-3420 engine of 3,000 horsepower. The result was the XP-75, an ill-fated aircraft that would enjoy neither good timing nor good fortune.

Tests soon proved that parts from

other planes were not suitable, and XP-75 went through a long series of time-consuming redesigning. The production version which emerged in September 1944 was a totally new aircraft, but one whose 404 mph top speed did not match the performance of the Mustangs or Thunderbolts already in mass production. The program was cancelled and the plane forgotten. Of the 14 Eagles built, only NASM's example remains. It is on exhibit at the Air Force Museum in Dayton, Ohio.

"MILESTONES" COVERS

For stamp and cover collectors, NASM produces a series of air and space commemoratives, with especially cacheted covers, each cancelled on the anniversary date of the event and at the historic place. For information and price list, write to "Milestones of Flight," (P701) at this Museum, full address on the back cover.

REGISTRATION for complimentary mailing of **Air & Space**, bimonthly (September-May) mini-magazine for educators

NAME _____

PLEASE PRINT

ADDRESS _____

ZIP CODE

Please check one box in each group:

POSITION

- ☐ Administrator, curator
- ☐ Teacher
- ☐ Staff member, educational organization (professional society, non-profit group or business)
- ☐ Editor, writer
- ☐ Other

SUBJECTS

- ☐ Sciences
- ☐ Aerospace in particular
- ☐ Other (social, arts, business, etc.)

LEVELS

- ☐ Kindergarten
- ☐ Primary
- ☐ Elementary or middle school
- ☐ High school or prep
- ☐ Adult (teachers' college, aerospace workshops, counseling, etc.)
- ☐ Wide range (as in museums)

AFFILIATION

- ☐ School, museum, planetarium
- ☐ Professional society, government, or
- ☐ Professional society, government, or non-profit organization
- ☐ Business

Air & Space is mailed at no cost to educators. Kindly fill out and mail the form to the left or a photocopy of it, to Room 3569 at the Museum (address on back cover). Forms may be photocopied in any quantity.

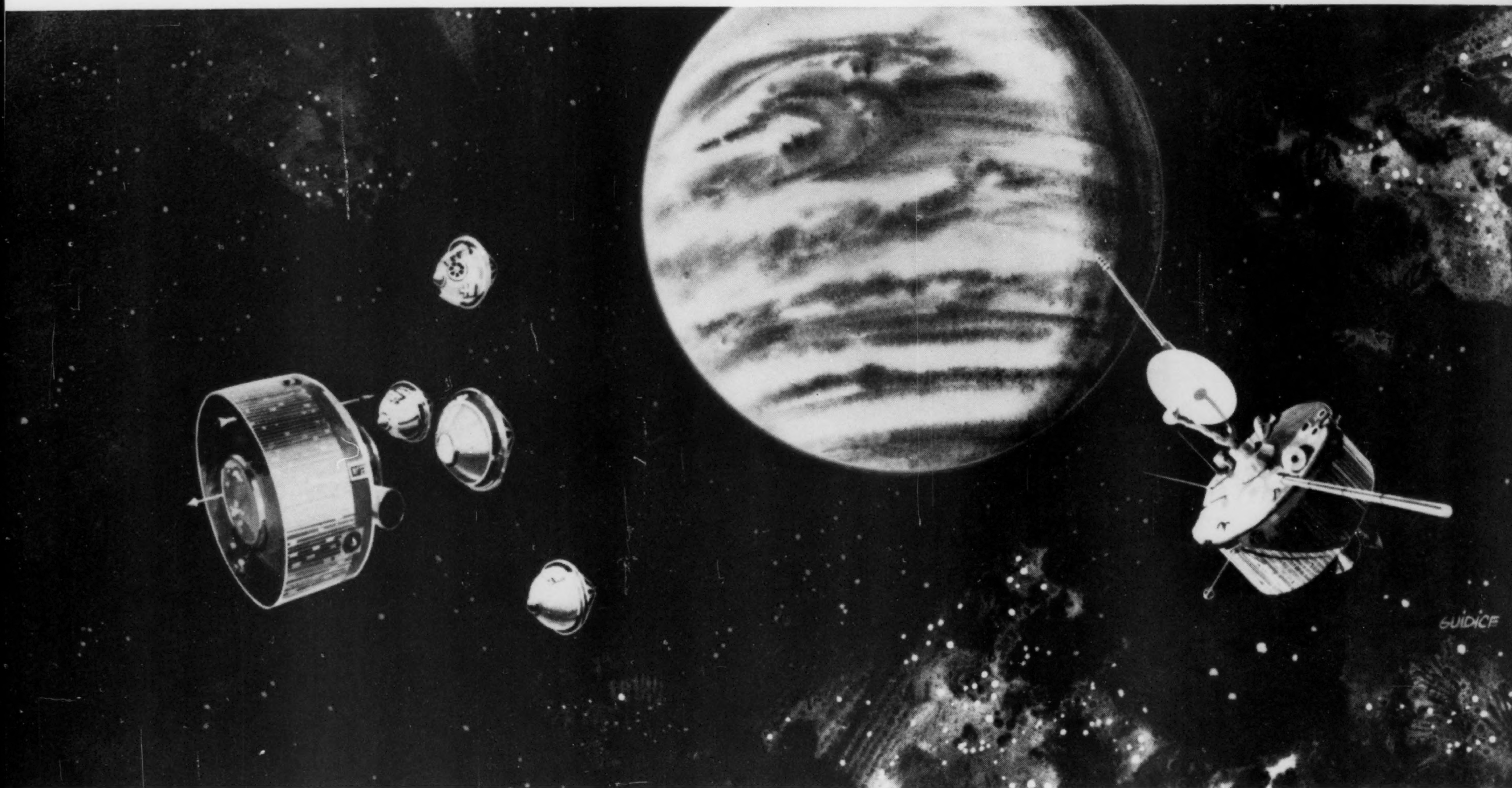
CREDITS:

Pages 1, 2, 3, 4, 5, 6, 7, 8, 13, 15: NASM historic files; gallery views and portraits by Dick Farrar and Dick Hofmeister.

Pages 3, 7, 8, 9, 11, 12, 16: NASA. Engine diagrams from NASA's Lewis Research Center, Cleveland, Ohio.

THINK ALONG WITH THE AEROSPACE ENGINEERS

How to explore a planet



Venus —

Ask students—how would they explore an Earth-size planet as weird as some in science fiction, but real. (See Page 11).

Since 1961, the U.S.S.R. has been sending spacecraft—11 launches, not counting whatever may have gone last August. The Soviets achieved the first successful unmanned landing on another planet there, May, 1969, just be-

fore the U.S. put astronauts on the Moon in July. In 1975, two Soviet landers survived long enough to send back the first and only two photographs ever made of the rocky Venusian surface (one, published in the May-June *Air & Space*). The Soviets have licked many problems concerning strength and heat resistance of their craft and scientific instruments.

Pioneer Venus 1 orbiter is the first

ever planned to remain in orbit as long as an entire Venusian year. The second Pioneer will eject its little probes while still 24 to 20 days away, and aim them so precisely that they will enter the Venusian atmosphere at four well-spaced areas across the hemisphere then visible to Earth. Their instruments will report independently about the plunge through various levels of that atmosphere.

Air & Space, Sept.-Oct. 1978

NATIONAL AIR AND SPACE MUSEUM
THE SMITHSONIAN INSTITUTION
WASHINGTON, DC 20560

Melvin B. Zisfein, Acting Director
Kerry M. Joels, Chief, Education Division

Julie Forbush, Editor, *Air & Space*

Air & Space is issued bimonthly through the school year, September-May, and is mailed on request, at no charge, to those associated with professional education. Contents may be freely photocopied for student use. Publication editors will be granted permission to reprint, on request. The staff welcomes letters and suggestions.

	Non-Profit Org.
	U.S. Postage
	Paid
	Permit No. 3055
	Beltsville, MD

